Volume 13 DECEMBER 1929 Number 12

BULLETIN

of the

American Association *of* Petroleum Geologists

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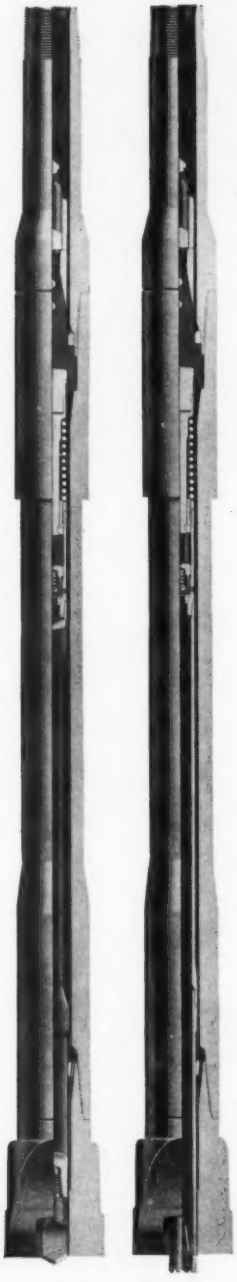

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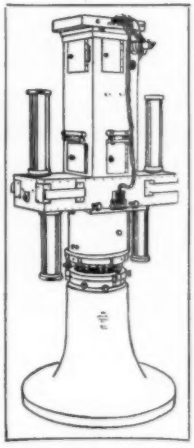

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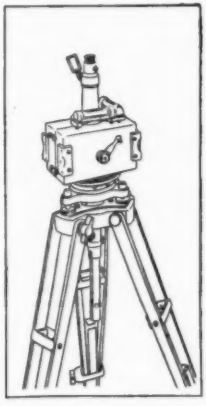

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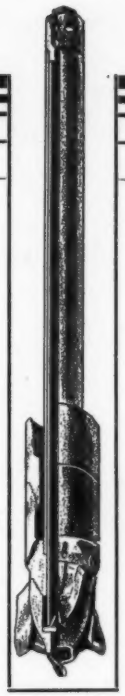

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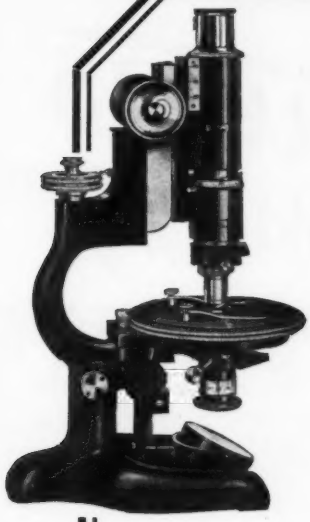

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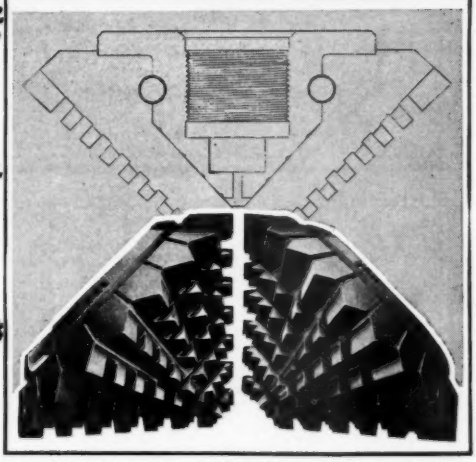

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BULLETIN

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AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

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By CLYDE M. BECKER

Age of Ouachita Orogeny and Its Tectonic Effects

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Similarity of Surface Geology in Front Range of Sierra Madre Oriental to Subsurface in Mexican South Fields

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Volume 13 Number 12

BULLETIN

of the

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

DECEMBER 1929

YATES OIL POOL, PECOS COUNTY, TEXAS[1]

RAY V. HENNEN[2] and R. J. METCALF[3]
Tulsa, Oklahoma, and Fort Worth, Texas

ABSTRACT

The Yates oil pool of northeastern Pecos County, Texas, was opened October 28, 1926, as a result of exploratory work stimulated by the discovery of the Big Lake oil pool of Reagan County. From the standpoint of high yield, low operating costs, and consequent remuneration, it is proving to be the most remarkable pool ever opened.

The oil production is from the Permian beds and the pool is located on a very prominent structure, domal in type, which is at the intersection of two structural ridges which are believed to be the result of differential subsidence around positive areas in the Permian basin.

The oil, which is approximately 30° gravity (A. P. I.), has qualities which, in spite of its sulphur content, make it desirable to refiners. It is chiefly from a thick and very porous pay zone in the Big Lake lime (Permian), but three higher zones are proving commercially productive. Conservation of gas in the pay zones and control of water problems by back pressure on the wells will greatly increase the yield of the pool.

The ultimate recovery is estimated at 640,000,000 barrels, with a much higher recovery probable.

Subsurface conditions make the Yates dome favorable for production in the lower Permian and in the deeper zones producing in the Big Lake field of Reagan County.

INTRODUCTION

The Yates pool is one of the most remarkable shallow-zone oil pools, from the standpoint of prolific production, ever developed, and it is an excellent example of oil and gas accumulation on anticlinal or domal structures and in an old buried land mass that had already been folded into a prominent ridge before subsidence.

[1]Manuscript received by the editor, August 14, 1929.

[2]Chief geologist, Transcontinental Oil Company, Tulsa, Oklahoma.

[3]Division geologist, Transcontinental Oil Company, with headquarters at Fort Worth, Texas.

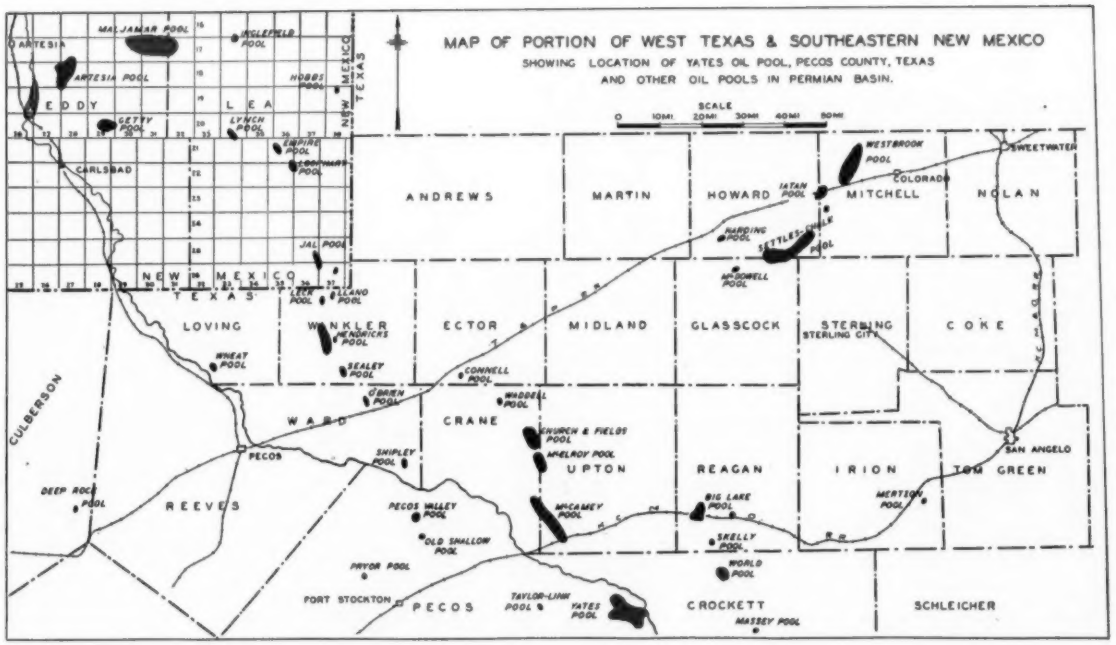

FIG. 1.—Map showing location of Yates and other pools in West Texas and southeastern New Mexico.

The pool is located (Fig. 1) in the northeast edge of Pecos County, Texas, about 30 miles south of the town of Rankin, on the Kansas City, Mexico and Orient Railway, and 30 miles southwest of the Big Lake pool of Reagan County.

A paper on the Yates pool, written by G. C. Gester and H. J. Hawley,[1] is now going through the press, but the writers of the present paper have not had access to it.

Acknowledgments are due for valuable data furnished by Frank R. Clark, chief geologist of the Mid-Kansas Oil and Gas Company, and to the several officials and employees of the companies operating in the field.

HISTORY

The Mid-Kansas Oil and Gas Company and Transcontinental Oil Company drilled the discovery well of the Yates pool (Fig. 2) in a solid block of 9,690 acres, the leaseholds on which are owned jointly, on a fifty-fifty basis. The block was acquired in the latter part of 1923 on the recommendation of the senior writer. The discovery well is located (Figs. 3, 4, 6, and 7) on what is known as the "vacancy strip" or I. G. Yates "A" lease, about 2,900 feet due west of the southwest corner of Survey 60, Block 1. It blew in unexpectedly in the top of the Big Lake lime at the shallow depth of 997 feet on October 28, 1926, with a large volume of gas and about 100 barrels of oil daily. Efforts were made immediately to mud off the oil and gas "pay" until the well could be properly cased. It required several days to do this and it was accomplished only after a large quantity of mud had been blown out of the hole several times. The well was then deepened to 1,032 feet and completed on December 13, 1926, making 135 barrels per hour. Later (August 18, 1928) it was completed to its present depth of 1,150 feet and its proration test at that time was 2,950 barrels of oil per hour. Its proration test in the latter part of June, 1929, still gives it 2,999.31 barrels per hour, or 71,984 barrels daily (Table II).

The completion of this remarkable well on such a large dome in the surface (Cretaceous) beds created great excitement in the oil fraternity, and development followed rapidly. By July 1, 1928, 207 wells had been completed in the pool with a daily potential production of 2,575,047 barrels of oil, based on one-hour open-flow tests, and by July 1, 1929, a total of 306 producing wells had been completed with a daily potential production of 4,590,686 barrels, or a daily potential production per well

[1] "Yates Field, Pecos County, Texas," *Structure of Typical American Oil Fields*, Vol. II, Amer. Assoc. Petrol. Geol. (1929).

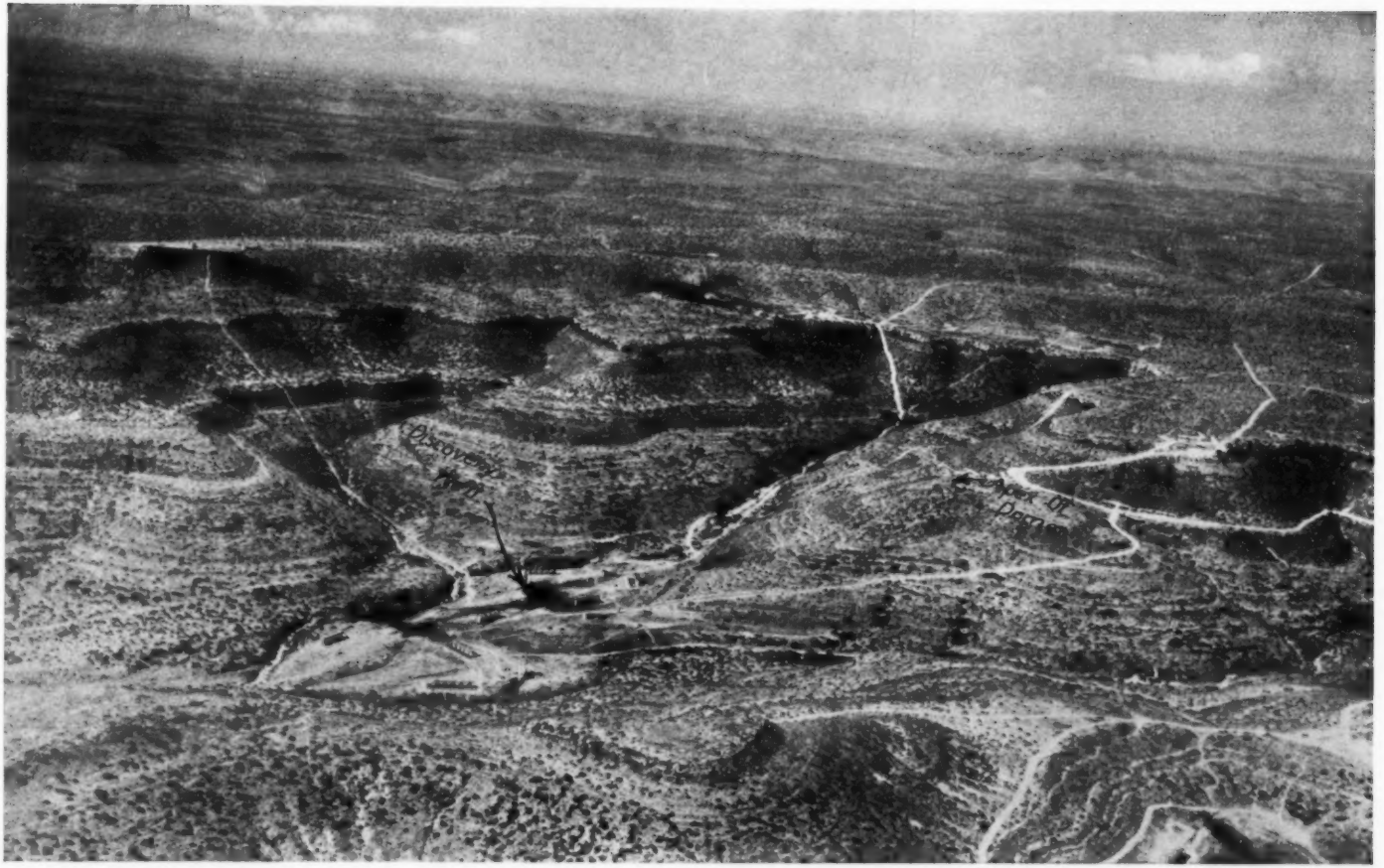

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FIG. 2.—Air-plane view of part of Yates oil field, looking southwest, showing topography, outcropping Cretaceous limestones, apex of dome, and discovery well (Mid-Kansas-Transcontinental's Yates "A" No. 1).

of 12,439 barrels and 14,620 barrels for the respective dates. No such results have ever been duplicated in so many wells in any pool, regardless of depth to pay zones.

PHYSIOGRAPHY

The Yates field lies in the dissected northwestern part of the Edwards plateau. Small intermittent tributaries to Pecos River have cut deep, steep-sided canyons into the Cretaceous limestones. The resistant cap-rock beds of the Edwards plateau country have formed topography of the flat-topped mesa type so familiar in this part of Texas (Fig. 2).

Visitors to the field are almost invariably surprised by the ruggedness of the topography in most of the producing area. Before the development of the field, the greater part of the producing area was inaccessible to vehicles and a considerable part of the earlier development expense was the cost of the building of a network of roads which now make all of the mesas, as well as the several canyons, easily accessible. Future drilling will require only short spurs of roadway to the individual locations.

The relief of the area ranges from an elevation of approximately 2,150 feet in the Pecos River bed to a maximum elevation of about 3,000 feet on the higher parts of the mesas. The greater part of this relief is found in the almost vertical cliffs of the mesas, but the extreme northern and eastern parts of the field are on a gently sloping alluvial plain which extends from the base of the mesas to Pecos River.

Although it is not readily apparent, the anticlinal structure of the surface beds (Fig. 6) has had a decided effect in shaping the erosional features of the area. A narrow, but very prominent, mesa extends along the axis of the structure from the vicinity of the southwestern corner of the Runnels County School Land tract (Fig. 6) to Section 33, Block 194. This long narrow ridge forms a divide south of which the drainage takes a circuitous course northwestward into Pecos River. The river has been shifted northward in a gentle circuit around the northern limit of the structure. In many other minor details the shaping of the mesas and the drainage channels have been affected by the structure.

STRATIGRAPHY

CRETACEOUS (COMANCHE)

The Cretaceous limestones exposed in the mesas of the field and immediate vicinity are about 620 feet in thickness and represent the series from the Mainstreet limestone, or upper cap rock, to the Comanche Peak and Walnut clays and limestones, the basal members of the series.

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This section resembles very closely that described in the Fort Stockton Quadrangle[1] except that the Kiamichi clay and associated clays and marls contain more limestone and the entire section is practically a solid body of limestone. However, the three main cap rocks are more resistant here and form distinct ledges capping the mesas.

Basement sands.—The Basement sands of the Cretaceous are exposed at several localities on the banks of Pecos River, north and east of the field. Only the upper parts are exposed, however, where they consist of ferruginous, medium- to coarse-grained sandstone. Well samples from them are light yellow, although the color at the outcrop ranges from reddish to gray. Calcareous horizons occur, especially near the base. The Basement sands range in thickness from about 50 to 180 feet.

TRIASSIC

Below the basal sands of the Cretaceous, and overlying the Permian beds unconformably, is a thin section of sands and clays, the age of which is somewhat in doubt. These beds range in thickness throughout the field from a negligible amount to more than 200 feet, and consist of irregularly bedded sands and clays. The predominant color is gray, although streaks of red clay are common. The sands are coarse-grained and subangular, and many samples appear mottled because of the dark minerals in them. The physical characteristics of this section and its stratigraphic position suggest that it is Triassic in age, and on the accompanying cross sections (Figs. 4 and 5) it has been given this classification.

PERMIAN

The Permian sediments encountered in the field represent a somewhat abbreviated section of those normally found in the Permian basin. Because of the structural relief existing during the deposition of the upper Permian, these strata become much thinner toward the axis of the fold, and the upper part of the sediments is almost entirely missing in part of the field.

Red-bed series.—The upper part of the section consists of a red-bed series containing many stringers of anhydrite. In this series are sandy phases and a few thin gray dolomite beds, both of which seem to be lenticular. A short distance above the base of this red-bed series occurs the Big, or Upper, salt of the Permian basin. This salt bed thins as the anticlinal structure of the field is approached and only a thin section of it appears at the borders of the field.

[1] W. S. Adkins, "Geology and Mineral Resources of the Fort Stockton Quadrangle," *Univ. of Texas Bull. 2738* (October 8, 1927).

In the central part of the field, this red-bed, anhydrite, and salt section is almost entirely missing (Figs. 4 and 5). The series thickens outward to approximately 400 feet in the limiting wells of the field. It continues to thicken within short distances in all directions away from the field and attains its normal thickness of more than 2,000 feet in the basins, where its deposition was not influenced by structural relief.

Yates sand.—A persistent sandy horizon, approximately 60 feet in thickness, underlies the red-bed series. This is known locally as the "Smith sand." The Yates is a shaly, calcareous sandstone in which occur seams of gypsum, dolomite, and anhydrite. It is gray to reddish-brown in color.

Anhydrite.—Below the base of the Yates sand occurs a thick and remarkably uniform deposit of anhydrite which has effectually formed an impervious layer over the Big Lake lime or producing horizon. It has an average thickness of approximately 475 feet. A few very thin dark gray dolomite lenses occur in this deposit. This dolomitic content increases near the base, where it forms a transitional phase from the gray dolomite of the Big Lake lime to the almost pure anhydrite above. On the flanks of the anticline the basal part of the anhydrite is sandy. The thickness of this sandy phase increases toward the borders of the field, where there are irregular patches of dolomitic sands which are a source of considerable production of oil. It reaches a thickness of more than 100 feet in a few localities, but in most of the field, is much thinner.

Both the distribution and the material of this sandy phase at the base of the anhydrite suggest a slight unconformity at the top of the Big Lake lime. The Yates anticline probably had its inception near the close of Big Lake lime time, and the structural relief produced then brought the limestone above or near the surface of the Permian sea. This permitted a limited amount of erosion and solution of the limestone, and the residual sands and considerable dolomitic materials were re-deposited somewhat irregularly along the flanks of the structural fold.

Big Lake lime.—The Big Lake lime of the Yates field is so named because it has been correlated (Fig. 4) with the formation of that name in the Big Lake field of Reagan County.[1] There is such a close resemblance in the stratigraphic sequence of beds in the two areas that this correlation seems highly reasonable. It is also thought to be the same limestone that is producing in the fields of Upton and Crane counties on the northwest. It is a gray dolomitic limestone which well samples

[1]The top of the "Big Lake lime" of this paper corresponds with the top of the "Brown lime" described in Gester and Hawley's paper on the Yates field in *Structure of Typical American Oil Fields*, Vol. II. These limestones seem to represent one horizon of the "Big lime" of the West Texas basin.—EDITOR.

show to be very uniform in color and texture in this part of the Permian basin. The oölitic structure of this limestone in the Big Lake field[1] and in the Crane County fields has not been noticed in the Yates field. The upper few feet of it, in many of the wells, is brown in color. This is probably discoloration from oil stain.

The agreement of operators to drill wells only 225 feet into the limestone has prevented exploratory work for deeper horizons; therefore, conditions in the limestone below the Big Lake pay zone and its total thickness are unknown. Because of its thickness in deep tests in this part of the basin, it is probable that at least 2,000 feet of it will be encountered in the field.

The gradual overlap of the upper Permian beds over the limestone in the Yates dome is shown in Figure 4. This overlap indicates that structural relief existed shortly after the limestone was deposited. This structural elevation probably produced some erosion from the top of the Big Lake lime, and it was doubtless this contact with surface waters and its consequent action on the limestone that produced the great porosity found in the pool.

Figure 5 shows a more detailed section of conditions in the field. The bed of anhydrite above the limestone, with its basal sandy phase, and the Yates sand maintain a fairly uniform thickness throughout the field and structurally conform very closely to contours on the Big Lake lime. The red-bed, anhydrite, and salt series above the Yates sand and below the unconformity at the base of the Triassic thicken gradually toward the structurally lower elevations of the pool.

DISCUSSION OF MAP (FIG. 3) AND CROSS SECTION (FIG. 4)

Considerable controversy formerly existed among geologists working in the West Texas area about the correlation of the producing limestone of the Yates pool with the Big Lake lime of the Big Lake pool of Reagan County, the top of which is 50-100 feet above the Texon discovery oil zone of the Big Lake pool. With this in mind the writers have prepared a cross section (Fig. 4) and map (Fig. 3) to accompany the section. This cross section is made from detailed logs of wells numbered serially from 1 to 16, inclusive, southwestward from the Big Lake pool across the Yates dome. At its northeast end the cross section begins with well No. 1, or the famous Texon Oil and Land Company's University No. 1-B, the deepest (8,525 feet) oil producer in the world. The list of wells (Table I) accompanying the cross section (Fig. 4) shows

[1]Ray V. Hennen, "Big Lake Oil Pool, Reagan County, Texas," *Structure of Typical American Oil Fields*, Vol. II, Amer. Assoc. Petrol. Geol. (1929).

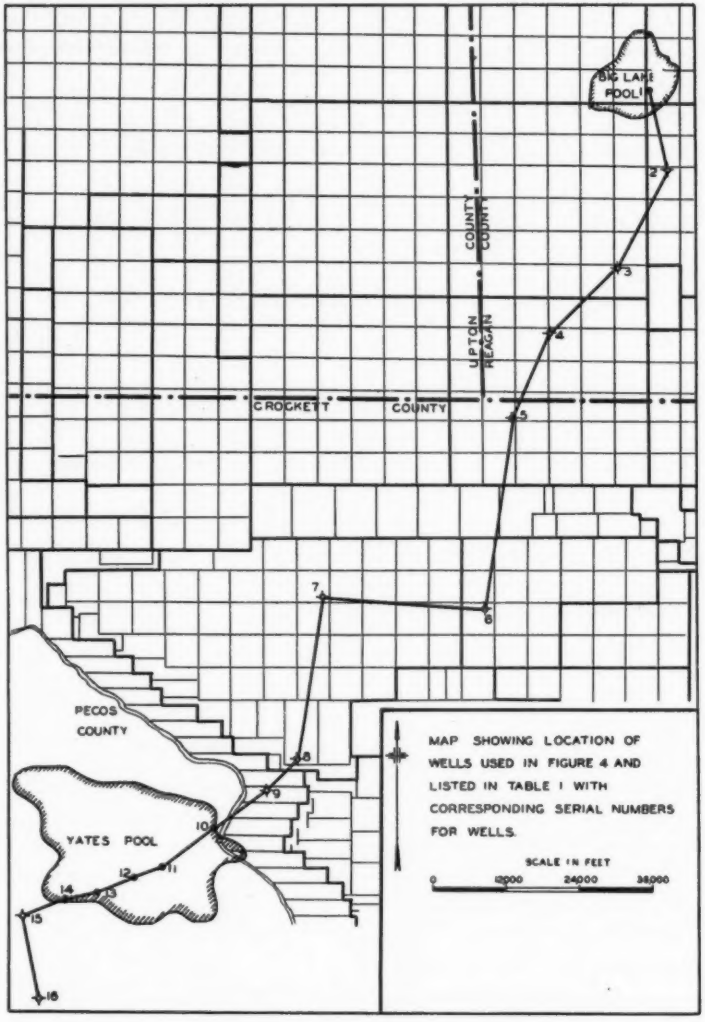

FIG. 3.—Map showing location of wells used in Figure 4.

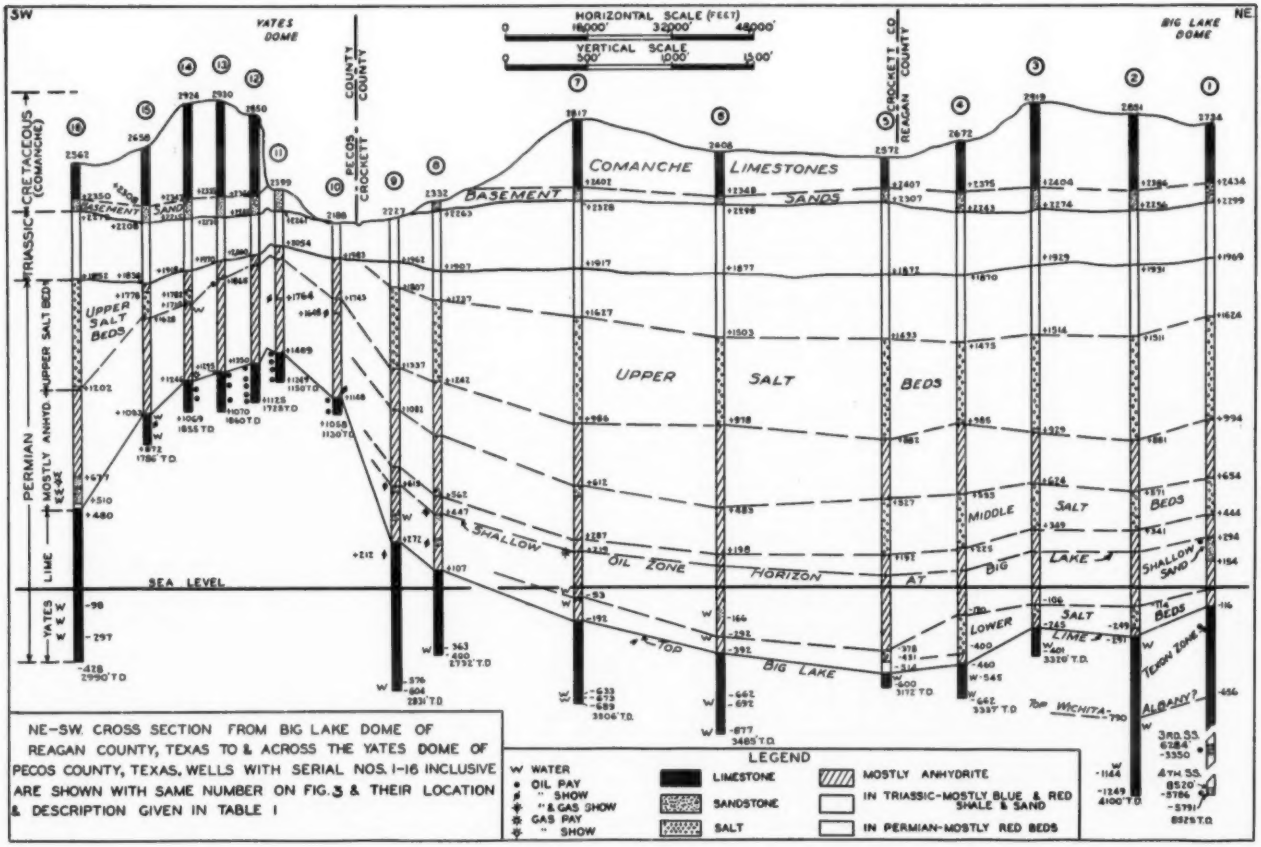

FIG. 4 —Cross section southwestward from Big Lake pool to Yates pool.

TABLE I

LIST OF WELLS SHOWN ON MAP (FIG. 3) AND ON CROSS SECTION (FIG. 4)

Serial Number	
	In Reagan County
1.	Texon O. & L. Co., Univ. 1-B, NW. cor., S. ½, Surv. 36, Blk. 10.
2.	The California Co., Univ. 1, NW. cor. NE. ¼, Surv. 13, Blk. 8, Univ.
3.	The Gulf Prod. Co., Univ. 1, NW. cor., Surv. 1, Blk. 1.
4.	Ark. Fuel Oil Co., Univ. 1, NW. ¼ of Surv. 9, Blk. 6, Univ.
	In Crockett County
5.	Endors-Smith, Univ. 1, SE. ¼, Surv. 23, Blk. 6, Univ.
6.	Cranfill Bros., Harris 1, Cent. NE. ¼, Surv. 4, Blk. 3, W. C. R. R.
7.	Mid-Kansas O. & G. Co., Harris 1, SE. ¼, Surv. 20, Blk. HH, G. C. & S. F. R. R.
8.	Gulf & Pure Oil Co., Thompson 1, S. border, Surv. 75, Blk. HH, G. C. & S. F. R. R.
9.	Gulf & Pure Oil Co., Thompson 1-A, N. border, Surv. 74, Blk. 1, I. & G. N. R. R.
	In Pecos County
10.	Mid-Kansas-Trans., Yates "D" 6. For loc. see Figs. 5 and 6.
11.	Mid-Kansas-Trans., Yates "A" 1. For loc. see Figs. 5 and 6.
12.	Mid-Kansas-Trans., Smith-Taylor 18. For loc. see Figs. 5 and 6.
13.	The California Co., Smith, Lse. 1-1, NW. ¼, Surv. 23, Blk. 194 (Fig. 6).
14.	Red Bank Oil Co., Smith 5, SW. cor. N. ½, Surv. 24, Blk. 194 (Fig. 6).
15.	The California Co., Smith 1, NE. ¼, Surv. 15, Blk. 194 (Fig. 6).
16.	Trans. & Ark. Fuel Oil, Perry 1, NE. cor. Surv. 5, Blk. Z, T. C. R. R.

the same serial numbers to designate the wells, and gives their ownership, name, and location in order. Figure 3 is a map showing the location of the 16 wells and, as explained in its title, the same serial numbers are used to designate the wells.

A study of this cross section (Fig. 4) reveals three important markers for correlation purposes, in wells 1-9, inclusive, in the upper Permian, namely, the "Upper," "Middle," and "Lower" salt beds. The Upper salt bed is persistent southwestward to the vicinity of the Yates dome, but the other two seem to thin away or undergo transition to anhydrite as the Yates dome is approached and are entirely absent on the crest and on the southwest flank of the dome. In wells 10-13, inclusive, the Upper salt bed is also absent on the crest of the anticline, but it begins to come into the section again in wells 14 and 15 and attains its full development in well No. 16 low down on the southwest flank of the structure. A careful study of the cross section indicates that there is little doubt that the top of the producing limestone corresponds with the top of the Big Lake lime, and they have been so correlated.

Another interesting feature shown by the cross section (Fig. 4) is the possibility that the shallow oil sand in well No. 1 is represented in wells 7, 8, and 9, and that it may be correlated with the sandy phase of the anhydrite which has produced much oil on flanks and noses of the Yates dome, as discussed on another page.

Well No. 1 is near the apex of the Big Lake dome. With this in mind, it is evident that the Yates dome is a much more pronounced structural feature than the Big Lake dome.

DISCUSSION OF CROSS SECTION (FIG. 5)

A northwest-southeast cross section, approximately along the major axis of the Yates dome, is shown by Figure 5. The detailed logs of 14 wells, all within Pecos County, were used. These have been numbered serially at the top from 1 to 14. Their location in the section is their projection at right angles to a straight line through wells 5, 9, and 14. As the ratio of the vertical scale to the horizontal is only 1 to 11, the structural relief is not so exaggerated as it appears on Figure 4, where the same ratio is 1 to 32.

By referring to the legend, it will readily be seen that this cross section (Fig. 5) gives a large amount of information as to the character of the beds penetrated and the horizons at which oil pay zones, oil showings, gas showings, water, et cetera, were encountered. The fault between wells 12 and 13 will be discussed on a subsequent page.

UNCONFORMITIES

Three marked unconformities are present in the strata of the Yates dome above the Big Lake lime.

The first unconformity in descending order is pronounced and occurs at the contact of the Cretaceous and Triassic (Figs. 4 and 5).

The second unconformity is at the contact of the Triassic and the red-bed section of the Permian (Figs. 4 and 5), and on the northeast flank of the dome is probably angular in character, as revealed by wells 8-11 inclusive (Fig. 5). The marked similarity of the sediments, both in color and physical appearance, makes it very difficult to place the contact of the Triassic and Permian, but in the cross sections (Figs. 4 and 5) it is believed its position is substantially correct.

The third unconformity is at the contact of the anhydrite-red-bed section of the Permian with the Big Lake lime. Its presence is strikingly illustrated by wells 8, 9, and 10 (Fig. 5) by the overlapping of beds on top of the Big Lake lime.

STRUCTURE

REGIONAL AND LOCAL FOLDING

The Yates pool is on a broad elliptical anticlinal feature which rises from the floor of the Permian basin to a structural relief of more than 1,500 feet. The Yates dome is only a segment of a continuous structural

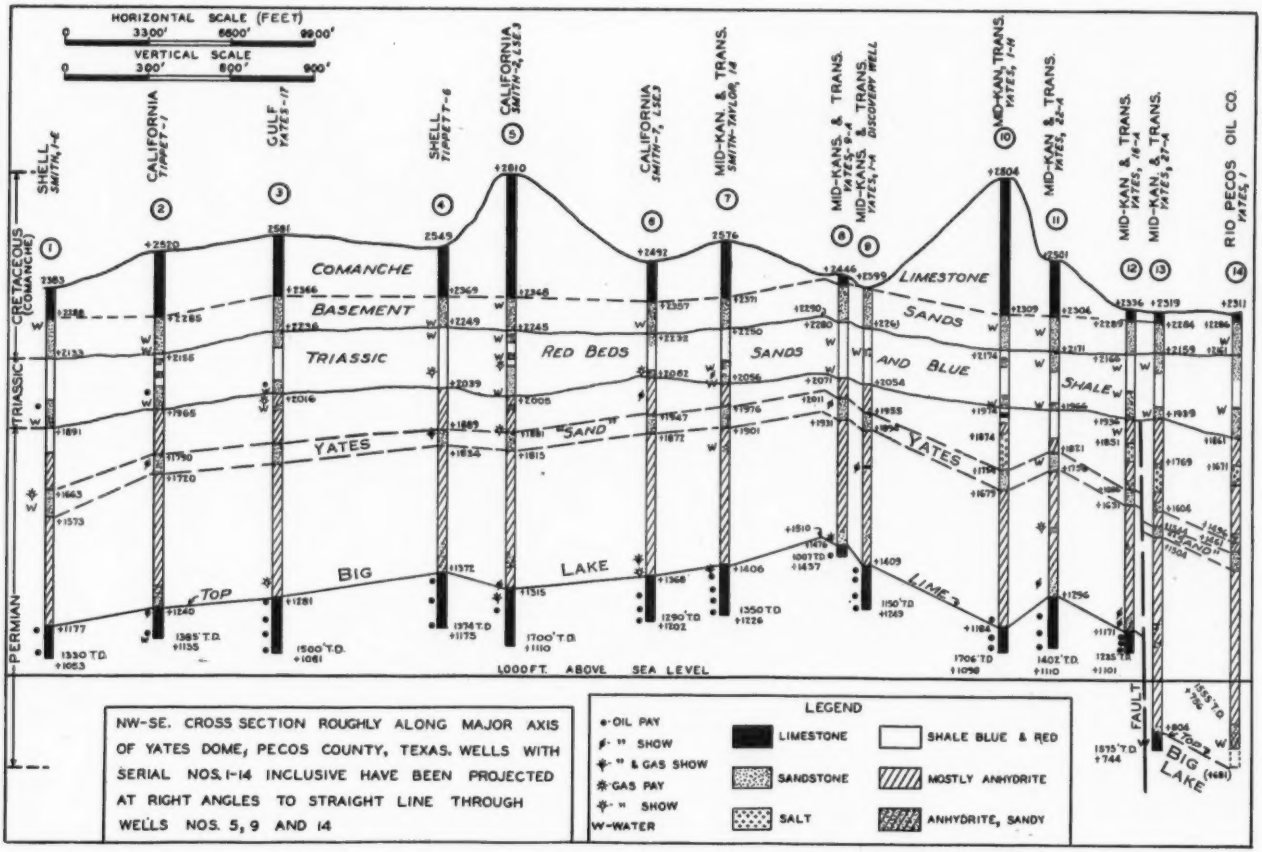

FIG. 5.—Northwest-southeast cross section on Yates dome.

ridge extending northwestward in a slightly crescentic course. The McCamey field, the fields of Crane County, and the Connell field in Ector County are along this structural ridge. The axis of this ridge rises gently southeastward from Ector County and has its culmination in the Yates dome. The northeastern flank of the Yates dome has a steep, rather abrupt descent into a deep basin in that direction, whereas the southwestern flank dips more gently into a shallower basin toward the southwest. This steep dip along the northeastern and eastern sides of the Yates structure and the gentler dip along its southwestern and western flank are strikingly illustrated on Figures 4 and 7.

Extending out of the southern part of the Yates dome is a structural ridge taking a westerly trend. Data available at the present time indicate that this ridge continues in a gently crescentic course through northern Pecos County, where it is locally known as the "Fort Stockton high," and thence into Ward and Winkler counties, Texas. Sedimentation on the flanks of this anticlinal ridge suggests that its elevation occurred at nearly the same time as that of the similar fold extending northwestward from the Yates field. The convergence of these two folds at the place where they cross in the Yates pool area has resulted in the extraordinary structural elevation attained there, and drainage from both these features has doubtless contributed to the exceptional accumulation of oil in the pool.

The theory held by some geologists that these two folds are the result of reef structure similar to the formations in the western side of the Permian basin[1] is largely discounted by the pronounced structure occurring in the Permian strata above the limestone and in the Triassic and Cretaceous beds. The thickening of the upper Permian sediments basinward from the folds suggests that these structural ridges are the result of differential subsidence, the structural ridges occurring over buried positive areas which remained at approximately the same elevation while the Permian basin as a whole was undergoing a progressive subsidence. This produced topographic relief along these positive areas which resulted in the thinning of deposits over the folds. The accentuated dip on the one side or the other of these folds has resulted from greater subsidence in the basin on that side.

[1]E. Russell Lloyd, "Capitan Limestone and Associated Formations of New Mexico and Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 13 (1929), p. 645. W. Grant Blanchard, Jr., and Morgan J. Davis, "Permian Stratigraphy and Structure of Parts of Southeastern New Mexico and Southwestern Texas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 13 (1929), p. 957.

It is also possible that uplift may have occurred locally along these lines and may have had considerable influence in shaping the structure in some localities.

DETAILED STRUCTURE ON SURFACE (CRETACEOUS) BEDS (FIG. 6)

The structural attitude of the surface (Comanche-Cretaceous) beds is shown for the Yates pool area on Figure 6. As explained in the northeast corner of the map, the datum key rock on which the contours are based is a limestone 370-380 feet above the top of the Basement sands. This limestone is 5-10 feet in thickness, and its top occurs 150 feet above the base of a marly division of the Edwards limestone series, this marly division ordinarily having a thickness of 175-190 feet. The base of this marly division rests on a heavy limestone nearly 300 feet in thickness, and at their contact this lower limestone forms a marked bench in the topography throughout its outcrop in northeastern Pecos County and the adjoining part of Crockett. The datum key is also widely persistent and during the last half of 1923 and early in 1924 it was used by the geologic staff of the Transcontinental Oil Company for contour mapping of the region extending from the Big Lake pool of Reagan County southwestward to the Yates pool area and beyond into northern Terrell County. This detailed mapping of the attitude of the Cretaceous beds was done by K. H. deCoussér under the immediate field supervision of A. M. Hagan and the senior writer. The actual outcrops run in the Yates pool area by deCoussér are shown by the dotted line (Fig. 6), this being the contact of the marly division and limestone previously mentioned. The area of outcrop run by deCoussér was sufficient to determine the major features of the dome in the Cretaceous beds, but it was not large enough to determine the true attitude of the Cretaceous beds in the entire area of the present developed pool. In the preparation of Figure 6, recourse then had to be taken to data revealed in well logs, both northeast and southwest of the outcrops run by deCoussér, supplemented by some outcrops (shown by dash and two-dot line in southwest corner and west border of Fig. 6) run during 1927 by Walter J. Boyle of the Transcontinental staff. From a careful study of the well logs, the elevation of the top of the Basement sands was determined in each, and to this was added 370-380 feet to get the elevation of the datum key, the interval ranging from about 370 feet in the west half to about 380 feet in the east half of the field.

It will readily be seen in comparing the resulting map (Fig. 6) with the one showing the contours on top of the Big Lake lime (Fig. 7) that

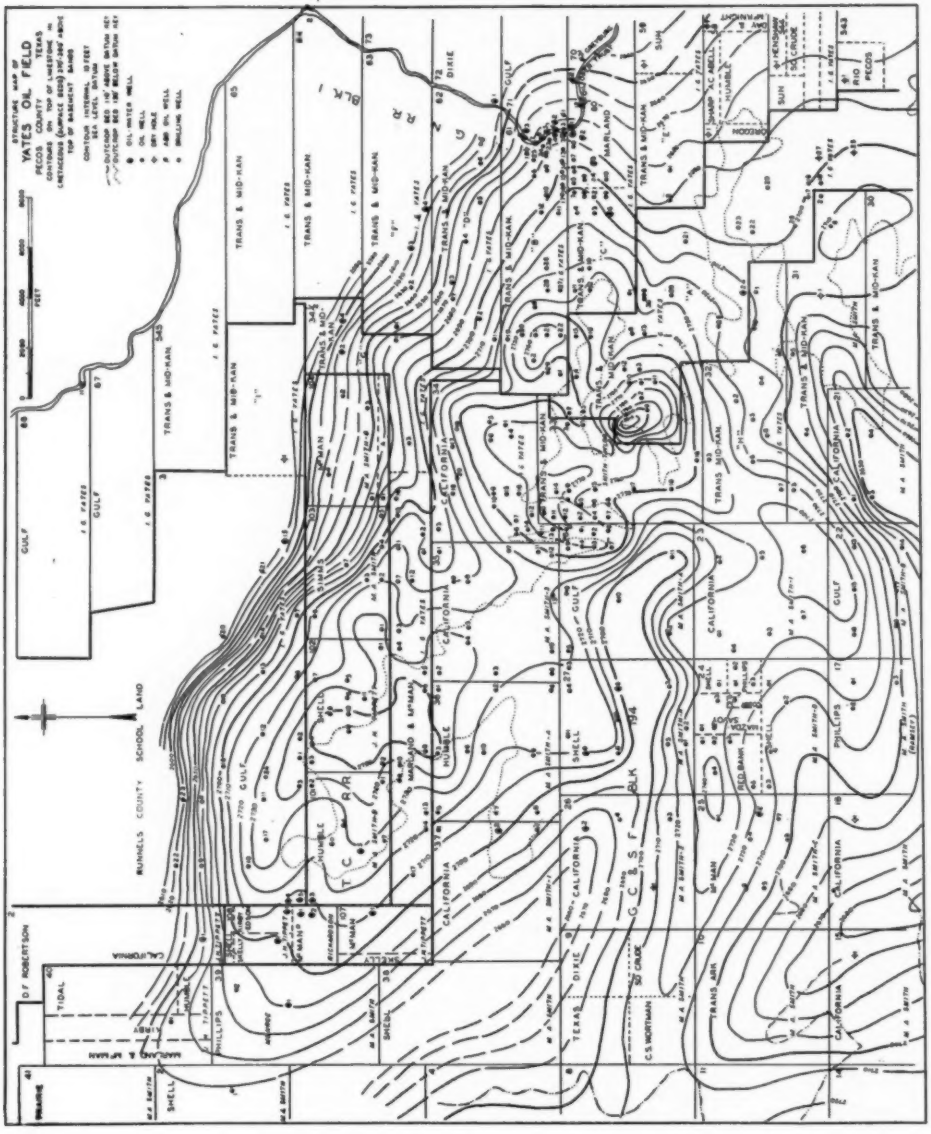

FIG. 6.—Contour map showing structure of surface (Cretaceous) beds.

there is a remarkable conformity, with the exception that the structural relief on the Big Lake lime is about three times as great. The location of the apex of the dome is the same on each map. The 2,700-foot contour is the lowest closure (Fig. 6) and the 2,810-foot, the highest; or there is a closure of 110 feet for the Yates dome in the surface beds.

DETAILED SUBSURFACE STRUCTURE ON BIG LAKE LIME (FIG. 7)

Figure 7, in addition to exhibiting all producing oil wells and dry holes within the limits of the map, gives contours showing the elevation above sea-level of the top of the Big Lake lime as revealed in all the completed wells.

In this connection, Table II, entitled "Development in Yates Pool," has been prepared. The headings for the table explain themselves and it will be readily observed that this table gives a large fund of valuable information for future reference for all the wells that have been completed in the field up to this time (August 8, 1929).

Under the "Elevation of the Derrick Floor" column, the figures used represent "Y-level" determinations by the engineering force of the Mid-Kansas Oil and Gas Company, with all elevations reduced to a common datum. For nearly all locations, the top of the Big Lake lime was determined from well cuttings by trained men in the field representing both the Mid-Kansas and Transcontinental companies, and under the column head "Depth to Top of Big Lake Lime," the figures used are from such determinations, and not from the driller's log. In this depth column, where parentheses are used, figures indicate an estimate of the depth to the Big Lake lime where the well in question has not yet penetrated to it. With such accurate subsurface data for the elevation of the datum key, in conjunction with the fact that a sufficient number of wells have been completed in all parts of the field to be representative, it is believed that the contours (Fig. 7) represent very closely the attitude of the Big Lake lime in the pool.

The contours indicate a doming in the Big Lake lime of much greater amplitude than in the Cretaceous beds (Fig. 6). From subsurface contour work completed throughout practically the entire northern half of Pecos County, outside the limits of the map (Fig. 7), it is believed that the plus 900-foot contour on the Big Lake lime represents the lowest closing contour, this critical point being about 7-8 miles westward from the Yates pool, seemingly in Sec. 36, Blk. Z, T. C. & R. R. Co. lands. This gives a closure of approximately 600 feet for the Yates dome, contrasted with 110 feet in the Cretaceous beds (Fig. 6).

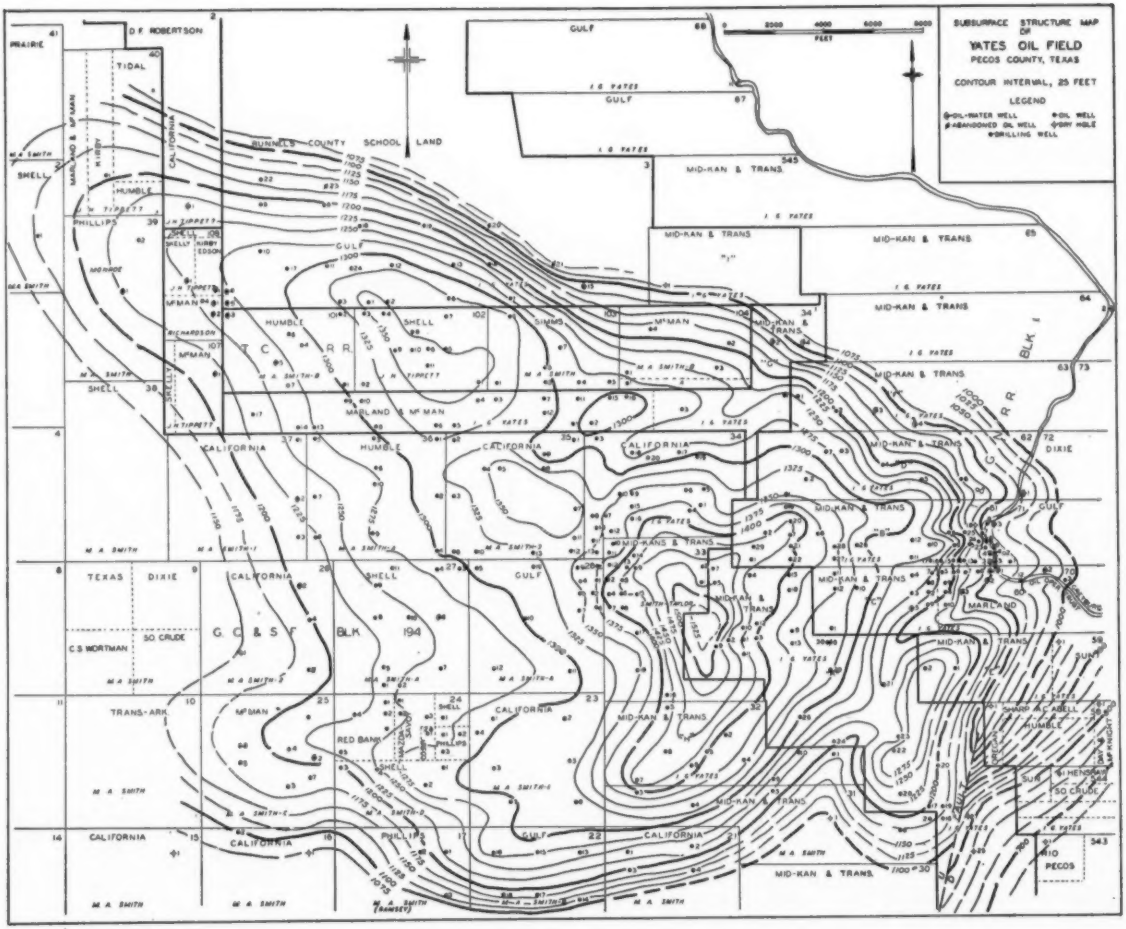

FIG. 7.—Contour map showing structure on top of Big Lake lime.

TABLE II
Development in Yates Pool.

Company and Lease.	Well No.	Elev. (A.T.) D.F.	Top of BIG LAKE Lm. Depth Ft.	Top of BIG LAKE Lm. Elev. Ft.	Bottom of Hole Depth Ft.	Bottom of Hole Elev. Ft.	Penetration in BIG L. Lm. -Ft.	Date of first completion.	Daily potential proration tests for 7-1-29 Bbls. - oil	Cross production by leases to 7-1-29 Bbls. - oil	Remarks
The California Company											
Yates - Sec. 34	1	2482	(1125)	(1357)	1040	1442	0	7-28-27	53202		Prod. from basal anhydrite only
" " "	2										Not yet drilled
" " "	3	2436	1144	1292	1274	1162	130	10-17-27	40344		Prod. from both basal anhydrite and Big Lake lime
" " "	4	2483	1100	1383	1190	1293	90	10-13-27	18070		Ditto
" " "	5	2452	(1100)	(1352)	1065	1387	0	10-22-27	20268		Prod. from basal anhydrite only
" " "	6	2542	1190	1352	1317	1225	127	12-17-27	10768		Prod. from basal anhydrite and Big Lake lime
" " "	7	2531	1180	1351	1205	1326	25	11-24-27	47096		Prod. from Big Lake lime only
" " "	8	2601	1269	1332	1370	1231	101	12-16-27	99676		" " " " " "
" " "	9	2559	1205	1354	1330	1229	125	2-2-28	21784		Prod. from Big Lake lime and basal anh.
" " "	10	2476	(1130)	1346	1055	1421	0	3-19-28	121796		Prod. from basal anhydrite
" " "	11	2571	1226	1345	1426	1145	200	2-8-28	7798		Prod. from Big Lake lime only
" " "	12	2553	1195	1358	1290	1263	95	2-12-28	24260		" " " " " "
" " "	13	2636	1266	1370	1482	1154	216	2-18-28	20236		" " " " " "
" " "	14	2622	1280	1342	1495	1127	215	3-22-28	13800		" " " " " "
" " "	15	2566	(1210)	1356	1125	1441	0	4-5-28	9926		Prod. from basal anhydrite only
" " "	16	2619	1230	1389	1367	1252	137	5-2-28	41278		" " Big Lake lime only
" " "	17	2416	1125	1291	1281	1135	156	10-17-28	6994		Prod. from Big Lake lime & basal anhy.
" " "	18	2525	1250	1275	1388	1137	138	9-2-28	55704		" " " " " only
" " "	19										Drilling (Aug. 8, 1929)
" " "	20										Drilling (" " ")
										3,969,039	
Smith-Lse.1-Sec.37	1	2529	1263	1266	1463	1066	200	1-25-28	2634		Prod. from Big Lake lime only
" " "	2	2699	1469	1230	1652	1047	183	4-11-28	860		" " " " " "
" " "	3	2570	1354	1216	1521	1049	167	5-29-28	60	194,968	" " " " " "

The California Co (cont'd)											
Smith-Lse 2-Sec. 26	1	2585	1433	1152	1595	990	162	4-12-28			Oil show in Big Lake lime with water, 1,508-26'; sul. watr., 1,588-95'. aband.
" " " " "	2	2584	1378	1206	1544	1040	166	7-25-28	50		Prod. from Big Lake lime only
" " " " "	3	2608	1416	1192	1565	1043	149	9-9-28	150		" " " " " ; oil and gas show in basal anhydrite
" " " " "	4	2621	1425	1196	1561	1000	136			50,939	Prod. from Big Lake lime only; Swabbing on 7-31-29
Smith-Lse.3- " 35	1	2536	1252	1284	1450	1086	198	10-5-27	11944		Prod. from Big Lake lime only
" " " "	2	2810	1495	1315	1700	1110	205	10-24-27	2104		" " " " " "
" " " "	3	2639	1335	1304	1535	1104	200	11-8-27	2526		" " " " " "
" " " "	4	2801	1465	1346	1675	1126	210	12-19-27	4054		" " " " " "
" " " "	5	2806	1445	1361	1648	1158	203	12-29-27	6870		" " " " " "
" " " "	6	2718	1416	1302	1619	1099	203	1-21-28	3218		" " " " " "
" " " "	7	2492	1124	1368	1290	1202	166	1-8-28	7612		" " " " " "
" " " "	8	2534	1213	1321	1400	1134	187	1-18-28	7240		" " " " " "
" " " "	9	2550	1272	1278	1470	1080	198	2-13-28	3428		" " " " " "
" " " "	10	2692	1372	1320	1572	1120	200	2-12-28	5322		" " " " " "
" " " "	11	2542	1199	1343	1400	1142	201	2-27-28	7860		" " " " " "
" " " "	12	2591	1250	1341	1455	1136	205	4-21-28	3898		5,400,000' of gas in lm. at 1,162-80'; oil prod. from Big Lake lime only
" " " "	13	2715	1395	1320						1,500,028	Drilling (Aug. 5, 1929)
Smith-Lse.1-Sec. 21	1	2610	1380	1230	1520	1090	140	2-21-29	12028		Prod. from Big Lake lime only
" " " " "	2	2582	1350	1232	1490	1092	140	2-10-29	3400		" " " " " "
" " " " "	3	2568	1382	1186	1476	1092	94	2-24-29	130		" " " " " "
" " " " "	4	2517	1377	1140	1410	1107	33	7-31-29		134,232	" " " " " "

The California Co.(cont'd)											
Smith-Lse. 5-Sec. 16	1	2672	1599	1073	2078	594	479	2-18-29	—		Dry hole; oil shows at 1,645-8', and at 1,715-23'
" " " " "	2	2649	1550	1099	1579	1070	29	4-20-29	20	375	Oil prod. from Big Lake lime only; oil and gas show near base anhydrite
" " 4-Sec. 15	1	2658	1605	1053	1786	872	181	1-21-29	—		Dry hole; slight oil show 1,664-6'
Smith-Lse. 1-Sec. 23	1	2820	1525	1295	1752	1068	227	7-4-28	248		Prod. from Big Lake lime only
" " " " "	2	2810	1505	1305	1695	1115	190	10-16-28	3342		" " " " " " Oil show in Yates sand
" " " " "	3	2844	1529	1315	1754	1090	225	11-6-28	3960		Prod. from Big Lake lime only; 263 bbls. oil in Yates sand at 1,010'
" " " " "	4	2930	1635	1295	1860	1070	225	12-3-28	2446		Prod. from Big Lake lime only; free oil 10 bbls. per hour in Yates sand
" " " " "	5	2930	1610	1320	1830	1100	220	1-6-29	2352		Prod. from Big Lake lime only; free oil in Yates sand, 1,090-1,100'
" " " " "	6	2938	1619	1319	1844	1094	225	1-17-29	3584		Prod. from Big Lake lime only
" " " " "	7	2950	1655	1295	1867	1083	212	2-28-29	4332	315,940	" " " " " "
Tippett -- Sec. 2	2	2520	1280	1240	1385	1135	105	10-12-28	70	9,257	" " " " " "
Gulf Production Co.											
Yates (RCS Land) "A"	1	2690	1325	1365	1540	1150	215	12-19-27	5802		Prod. from Big Lake lime only
" "	2	2569	1224	1345	1349	1220	125	12-4-27	32856		" " " " " "
" "	3	2552	1225	1327	1390	1162	165	11-29-27	2240		" " " " " "
" "	4	2550	1272	1278	1421	1129	149	1-11-28	50		" " " " " "
" "	5	2522	1263	1259	1412	1110	149	1-12-28	50		" " " " " " and basal anhydrite
" "	6	2554	1230	1324	1425	1129	195	1-28-28	26922		Prod. from Big Lake lime only
" "	7	2397	1130	1267	1266	1131	136	1-9-28	16204		Prod. from Big Lake lime & basal anhy.
" "	8	2377	1178	1199	1283	1094	105	3-21-28	438		" " " " " "; good oil show at 445-440'
" "	9	2433	1230	1203	1300	1133	70	7-25-28	390		Prod. from Big Lake lime only; oil show at 350-400'
" "	10	2443	1155	1288	1330	1113	175	8-3-28	1092		Prod. from Big Lake lime only

Gulf Production Co (cont'd)											
Yates (RCS Land) A	11	2429	1125	1304	1328	1101	203	7-17-28	3554		Prod. from Big Lake lime only
" "	12	2432	1110	1322	1331	1101	221	8-9-28	10644		" " " " " "
" "	13	2445	1175	1270	1280	1165	105	7-22-28	115272		Prod. from Big Lake lime and basal anhydrite; 15 mil. gas 1,065-1,105
" "	14	2372	1150	1222	1265	1107	115	7-19-28	6244		Prod. from Big Lake lime only
" "	15	2353	(1240)	1113	1237	1116	0	9-14-28	31994		" " basal anhydrite
" "	17	2581	1300	1281	1500	1081	200	8-27-28	3460		" " Big Lake lime only; good show oil and gas 465-525'
" "	18	2388	1150	1238	1310	1078	160	9-3-28			Initial prod. 50 bbls. per hr. from Big Lake lime; acreage allow. 204 bbls. 7-1-29
" "	19	2401	1205	1196	1317	1084	112	9-14-28	—		I. P. 225 bbls. per hr. fr. Big Lake lime; good oil show 490-510'
" "	20	2332	1262	1070	1324	1008	62	10-31-28	—		Temp. aband. as dry hole; water 1,310-24'
" "	21	2348	1318	1030	1375	973	57	11-2-28	—		Temp. aband. as dry hole; 20 bbls. oil flow at 1,307'; water, 1,362'
" "	22	2474	1315	1159	1418	975	103	11-8-28	100		Prod. from Big Lake lime only
" "	23	2362	1195	1167	1291	1071	96	11-1-28			Temp. aband. as dry; flowed 100 bbls. per hr. from 1,237-91'—70% water
" "	24	2567								3,621,426	
Smith-Lse. A-Sec. 28	1	2636	1253	1383	1480	1156	227	9-23-27	17966		Prod. from Big Lake lime only
" " " " "	2	2659	1288	1371	1508	1151	220	12-13-27	5514		" " " " " "
" " " " "	3	2819	1488	1331	1688	1131	200	1-7-28	10676		" " " " " "
" " " " "	4	2617	1255	1362	1425	1192	170	12-29-27	16420		" " " " " "
" " " " "	5	2810	1500	1310	1702	1108	202	1-20-28	1672		" " " " " "
" " " " "	6	2836	1465	1371	1675	1161	210	1-29-28	5564		" " " " " "
" " " " "	7	2850	1500	1350	1720	1130	220	1-29-28	3746		" " " " " "
" " " " "	8	2640	1265	1375	1489	1151	224	2-3-28	10198		" " " " " "
" " " " "	9	2588	1230	1358	1430	1158	200	2-26-26	8272		" " " " " "

Gulf Prod. Co. (Cont'd)											
Smith-Lse. "A" – Sec. 28	10	2739	1435	1304	1640	1099	205	8-2-28	1256		Prod. from Big Lake lime only
" " " " "	11	2934	1650	1284	1870	1064	220	8-31-28	408		" " " " " "
" " " " "	12	2715	1446	1269	1671	1044	225	10-8-28	110		" " " " " "
" " " " "	19	2746								1,308,541	Drilling at 715'—8-8-29
Smith-Lse. "B" – Sec. 22	13	2648	1386	1262	1521	1127	135	1-16-29	12290		Prod. from Big Lake lime & bas. anhy.
" " " " "	14	2654	1535	1119	1550	1104	15	3-15-29	120		" " " " " " " "
" " " " "	15	2681	1405	1276	1580	1101	175	3-24-29	6112		" " " " " " " "
" " " " "	16	2813	1530	1283	1713	1100	183	4-21-29	2402		" " " " " " " "
" " " " "	17	2670	1480	1190	1576	1094	96	6-18-29	6070		" " " " " " " "
" " " " "	18	2690	1500	1190	1597	1093	97	6-21-29	2014	172,972	" " " " " " " "
Thompson – Sec. 71	1	2153	(1068)	1085	988	1165	0	9-15-27			Prod. from basal anhyd.—I. P. 450 bbls. per hour. Later plugged and aband.
" " "	2	2154	(1069)	1085	940	1214	0	10-28-27	408		Prod. from basal anhyd.
" " "	3	2166	(1066)	1100	1042	1124	0	12-17-27		243,615	" " " "
Humble Oil & Ref. Co.											
Smith-"A" – Sec. 36	1	2724	1398	1326	1600	1124	202	10-1-27	2538		Prod. from Big Lake lime only
" " " "	2	2622	1309	1313	1510	1112	201	11-7-27	1546		" " " " " "
" " " "	3	2591	1305	1286	1480	1111	175	11-17-27	8600		" " " " " "
" " " "	4	2791	1480	1311	1670	1121	190	12-14-27	3866		" " " " " "
" " " "	5	2539	1265	1274	1480	1059	215	12-19-27	3058		" " " " " "
" " " "	6	2573	1266	1307	1446	1127	180	1-23-28	9090		" " " " " "
" " " "	7	2775	1528	1247	1693	1082	165	4-22-28	774		" " " " " "
" " " "	8	2582	1358	1224	1500	1082	142	5-24-28	402		" " " " " "

Humble O & Ref. Co (cont'd)											
Smith-"A"-Sec. 36	9	2798	1509	1289	1685	1113	176	9-15-28	1842		Prod. from Big Lake lime only
" " " "	10	2572	1280	1292	1420	1152	140	10-19-28	5660	997,489	" " " " " "
Smith-"B"-Sec. 101	1	2618	1311	1307	1512	1106	201	12-12-27	2724		" " " " " "
" " " "	2	2557	1240	1317	1451	1106	211	12-1-27	3032		" " " " " "
" " " "	3	2522	1250	1272	1460	1062	210	1-1-28	358		" " " " " "
" " " "	4	2804	1512	1292	1722	1082	210	2-15-28	1610		" " " " " "
" " " "	5	2598	1310	1288	1458	1140	148	7-12-28	320		" " " " " "
" " " "	6	2816	1544	1272	1688	1128	144	Avg. - 29			62 bbls. per hr. from Big Lake lime
" " " "	7	2575	1280	1295						559,763	Drilling (8-8-20)
Marland Oil Co. (Now Continental)											
Yates-"A" Lse.-Sec. 60	1	2178	(1078)	1100	1024	1154	0	8-18-27	—		I.P. 415 bbls. per hr. from basal anhyd. Plugged and abandoned
" " " " "	2	2177	(1077)	1100	1045	1132	0	10-31-27	4472		Prod. from basal anhydrite
" " " " "	3	2210	(1078)	1125	1148	1062	63	11-1-27	—		" " basal anhyd., 720 bbls. fluid—35% water
" " " " "	4	2222	1022	1200	1055	1167	33	11-3-27	4146		Prod. from Big Lake lime & bas. anhyd.
" " " " "	5	2205	985	1220	1016	1189	31	12-6-27	34080		" " " " " " " flowed oil at 625-35' in up. anhyd.
" " " " "	6	2182	982	1200	1033	1149	51	12-4-27	1826		Prod. from Big Lake lime & bas. anhyd.
" " " " "	7	2192	1022	1170	1110	1082	88	12-4-27	1268		" " " " " " " "
" " " " "	8	2201	1061	1140	1058	1143	0	12-6-27	828		Prod. " basal anhyd. only
" " " " "	9	2198	(985)	1213	1030	1168	45	12-14-27	5136		" " Big Lake lime only
" " " " "	10	2225	1040	1185	1038	1187	0	12-14-27	10396	931,159[a]	" " basal anhyd. only (a) includes 306,136 bbls. seepage oil
Marland & McMan Cos.											
Yates-W. part Sec. 34 ½	1	2524	1227	1297	1394	1130	167	8-9-27	66552		Prod. from Big Lake lime only

Marland & McMan Cos.											
Yates-W. part Sec. 34½	2	2510	1204	1306	1382	1128	178	10-14-27	70448		Prod. from Big Lake lime only
" " " "	3	2531	1202	1329	1427	1104	225	10-1-27	3960		" " " " " "
" " " "	4	2571	1228	1343	1479	1092	251	9-30-27	5302		" " " " " "
" " " "	5	2819	1480	1339	1695	1124	215	10-14-27	3800		" " " " " "
" " " "	6	2760	1420	1340	1632	1128	212	10-14-27	3322		" " " " " "
" " " "	7	2497	1197	1300	1393	1104	196	11-25-27	15160		" " " " " "
" " " "	8	2617	1301	1316	1504	1113	203	11-20-28	5878		" " " " " "
" " " "	9	2601	1312	1289	1500	1101	188	11-2-28	2810		" " " " " "
" " " "	10	2627	1320	1307	1510	1117	190	11-27-27	4216		" " " " " "
" " " "	11	2433	1152	1281	1302	1131	150	12-8-27	48380		" " " " " "
" " " "	12	2535	1225	1310	1431	1104	206	12-14-27	4712		" " " " " "
" " " "	13	2549	1275	1274	1483	1066	208	12-22-27	1532		" " " " " "
" " " "	14	2536	1285	1251	1450	1086	165	12-24-27	1500		" " " " " "
" " " "	15	2487	1185	1302	1349	1138	164	1-12-28	55822		" " " " " "
" " " "	16	2395	1090	1305	1270	1125	180	5-27-28	69996		" " " " " "
" " " "	17	2515	1272	1243	1421	1094	149	7-12-28	510	2,629,378	" " " " " "
McMan Oil & Gas Co.											
Smith-"A" Lse-Sec. 104	1	2458	1175	1283	1293	1165	118	5-27-28	80188	389,500	Prod. from Big Lake lime only
" "B" " Sec. 104	1	2476	1206	1270	1372	1104	166	5-15-28	8878		" " " " " & bas. anh.
" " " " "	2	2340	1155	1185	1228	1112	73	6-21-28	6578		" " " " " " " "
" " " " "	3	2342	1100	1242	1242	1100	142	7-11-28	6036		" " " " " " " "
" " " "	4	2423	1235	1188	1305	1118	70	7-29-28	1692	550,530	Prod. from Big Lake lime only

McMan O&G Co.(cont'd)											
Smith-"C" Lse.-Sec. 25	1	2680	1473	1207	1587	1093	114	6-28-28	896		Prod. from Big Lake lime only
" " " " "	2	2849	1649	1200	1737	1112	88	11-15-28			Oil prod. from Big Lake lime & basal anhyd. 25 mil. gas 1,470-1,590'
" " " " "	3	2784	1600	1184	1694	1090	94	1-7-29	746		Prod. from Big Lake lime only
" " " " "	4	2833	1613	1220	1705	1128	92	1-17-29	300		" " " " " " " 25 mil. gas at 1,401-1,505' "
" " " " "	5	2787	1605	1182	1697	1090	92	4-24-29	1134		Prod. from Big Lake lime only
" " " " "	6	2839	1662	1177	1760	1079	98	7-21-29	200		" " " " " "
" " " " "	7	2782	(1592)	1190	1635	1147	43	7-8-29		179,569	I. P. 100 bbls. from Big Lake lime; 16 mil. gas from basal anhyd. 1,500-1,530
Richardson-Sec. 108	1	2526	1280	1246	1450	1076	170	1-4-28	626		Prod. from Big Lake lime only
" " "	2	2510	1255	1255	1395	1115	140	2-10-28	140		" " " " " "
" " "	4	2522								57,845	Drilling (Aug. 8, 1929)
" " 107	3	2506	1295	1211	1372	1134	77	10-3-28	240	122,433	Prod. from Big Lake lime only
Mid-Kansas & Transcontinental											
Yates-"A" Lease	1	2399	990	1409	1150	1249	160	12-13-26	71984		" " " " " " Discovery well, on Oct. 28, '26
" " "	2	2423	989	1434	1001	1422	12	2-11-27	18908		Prod. from Big Lake lime only; gas at 880'
" " "	3	2380	992	1388	1217	1163	225	3-12-27	21002		Prod. from Big Lake lime only
" " "	4	2554	1135	1419	1330	1224	195	6-22-27	34690		" " " " " "
" " "	5	2636	1160	1476	1355	1281	195	8-19-27	41252		" " " " " "
" " "	6	2294	950	1344	1045	1249	95	6-23-27	——		Plugged; potential 83,082 bbls. daily
" " "	7	2682	1220	1462	1277	1405	57	8-18-27	34958		Prod. from Big Lake lime only
" " "	8	2426	1070	1356	1117	1309	47	12-14-27	42168		" " " " " "
" " "	9	2446	970	1476	1009	1437	39	11-27-27	394		Prod. from top Big Lake lime; 20 mil. gas 950-60' in basal anhyd.
" " "	10	2422	986	1436	1077	1345	91	1-19-28	37954		Prod. from Big Lake lime only

Mid-Kansas & Transcontinental											Prod. from Big Lake lime only
Yates "A" Lease	11	2099	951	1448	1180	1219	229	1-11-28	40276		" " " " " "
" " "	12	2380	975	1405	1200	1180	225	1-19-28	9856		" " " " " "
" " "	13	2316	950	1366	1180	1136	230	1-27-28	17842		" " " " " "
" " "	14										Location not yet drilled
" " "	15	2627	1240	1387	1495	1132	255	2-7-28	32142		Prod. from Big Lake lime only
" " "	16	2336	1158	1178	1235	1101	77	3-5-28	23726		" " " " " "
" " "	17	2338	1138	1200	1240	1098	102	4-20-28	188		Prod. from Big Lake lime & bas. ank.
" " "	18	2611	1225	1386	1450	1161	225	6-6-28	41612		" " " " " only
" " "	19	2329	(1150)	1179	1104	1225	0	5-23-28	58218		" " basal anhyd.
" " "	20	2370	1170	1200	1270	1100	100	6-28-28	774		" " Big Lake lime only
" " "	21	2373	1152	1221	1240	1133	88	7-13-28	2624		" " " " " "
" " "	22	2501	1205	1296	1402	1099	197	7-12-28	12296		" " " " " "
" " "	23	2442	1195	1247	1342	1100	147	7-23-28	9780		" " " " " "
" " "	24	2777	1570	1207	1678	1099	108	8-4-28	1564		" " " " " "
" " "	25	2322	1550	772	1630	692	80	7-25-28			Dry hole
" " "	26	2700	1400	1300	1465	1235	65	5-3-29	86212		Prod. from Big Lake lime only
" " "	27	2319	1515	804	1575	744	60	4-22-29			Dry hole
" " "	28	2471	(1235)	1236	1195	1276	0	6-18-29	19812		Prod. from Big Lake lime only
" " "	29	2336	1020	1316	1220	1116	200	6-18-29	13648		" " " " " "
" " "	30	2298			280	2018		7-20-29		6,233,344	Pumping 75 bbls.—280'—8-8-29
Yates "B" Lse. Sec. 61	1	2612	1185	1427	1410	1202	225	2-4-27	17958		Prod. from Big Lake lime only
" " " " "	2	2550	1130	1420	1422	1128	292	2-24-27	5488		" " " " " "

Mid-Kansas & Transcontinental											
Yates "B" Lse. Sec. 61	3	2153	(1030)	1123	913	1240	0	8-16-27	7772		Prod. from basal anhydrite
" " " " "	4	2156	(1035)	1121	917	1239	0	10-29-27	400		" " " "
" " " " "	5	2161	990	1171	1066	1095	76	11-14-27	4536		Prod. from Big Lake lime & bas. anh.
" " " " "	6	2208	1000	1208	1072	1136	72	11-7-27	4116		" " " " " " " "
" " " " "	7	2529	1104	1425	1268	1261	164	12-10-27	58636		" " " " " " only
" " " " "	8	2357	980	1377	1075	1282	95	12-2-27	64536		" " " " " " & basal an.
" " " " "	9	2214	980	1234	1080	1134	100	11-18-27	12338		" " " " " " only
" " " " "	10	2520	1230	1290	1313	1207	83	2-15-28	12102		" " " " " " " "
" " " " "	11	2583	1290	1293	1386	1197	96	2-8-28	13236		" " " " " " " "
" " " " "	12	2515	1223	1292	1333	1182	110	3-1-28	14784		" " " " " " " "
" " " " "	13	2179	1040	1139	1040	1139	0	12-17-27	332		" " " basal anhydrite
" " " " "	14	2175	1030	1145	1042	1133	12	12-17-27	896		" " " Big Lake lime only
" " " " "	15	2191	1000	1191	1044	1147	44	12-5-27	5250		" " " " " "
" " " " "	16	2227	970	1257	1050	1177	80	12-10-27	11210		" " " " " "
" " " " "	17	2278	1010	1268	1075	1203	65	12-28-27	30524		" " " " " "
" " " " "	18	2151	1047	1104	1108	1043	61	1-18-28			Dry hole
" " " " "	19	2546	1160	1386	1390	1156	230	2-25-28	21218		Prod. from Big Lake lime only
" " " " "	20	2590	1150	1440	1376	1214	226	2-8-28	30816		8 mil. gas 1,110-1,125' in anhyd. Oil prod. from Big Lake lime only
" " " " "	21	2397	997	1406	1149	1248	152	2-21-28	21834		Prod. from Big Lake lime only
" " " " "	22	2561	1155	1406	1285	1276	130	3-21-28	20386		" " " " " "
" " " " "	23	2155	(1040)	1115	995	1160	0	1-20-28	128		" " " basal anhydrite
" " " " "	24	2154	1034	1120	1035	1119	1	1-25-28	336		" " " "

Mid-Kansas & Transcontinental											
Yates "B" Lse. Sec. 61	25	2158	1000	1158	1040	1118	40	1-24-28	2328		Prod. from Big Lake lime only
" " " " "	26	2516	1215	1301	1390	1126	175	7-14-28	14496		" " " " " " "
" " " " "	27	2597	1235	1362	1414	1183	179	1-16-29	57298		Prod. from Big Lake lime & bas. anh.
" " " " "	28	2594	1230	1364	1325	1269	95	2-25-29	88562	3,731,564	" " " " " " " "
Yates "C" Lse. Sec. 60	1	2232	1000	1332	1182	1150	182	5-16-27	8732		" " " " " only
" " " " "	2	2215	985	1230	993	1222	8	11-11-27	15112		" " " " " & basal anh.
" " " " "	3	2256	1000	1256	1150	1106	150	11-15-27	2208		" " " " " only
" " " " "	4	2356	1100	1256	1144	1212	44	12-24-27	28304		" " " " " "
" " " " "	5	2235	1010	1225	1130	1105	120	11-24-27	10516		" " " " " "
" " " " "	6										Location not yet drilled
" " " " "	7	2231	975	1256	1091	1140	116	12-2-27	9704		Prod. from Big Lake lime only
" " " " "	8	2222	(1082)	1140	983	1239	0	12-7-27	125854		" " basal anhydrite
" " " " "	9	2220	(1020)	1200	960	1260	0	12-12-27	20712		" " " "
" " " " "	10	2522	1200	1322	1295	1227	95	7-9-28	102328		" " Big Lake lime only
" " " " "	11	2562	(1197)	1365	1175	1387	0	11-30-28	58272		" " basal anhydrite
" " " " "	12	2602	1245	1357	1362	1240	117	2-4-29	110886	2,499,568	Prod. from Big Lake lime & bas. anh.
Yates "D" Lse. Sec. 62	1	2529	1180	1349	1330	1199	150	11-16-27	12284		" " " " " " " "
" " " " "	2	2518	1180	1338	1296	1222	116	1-13-28	42852		Prod. from Big Lake lime only
" " " " "	3	2512	1250	1262	1395	1117	145	7-25-28	11564		" " " " " & bas. anh.
" " " " "	4	2271	1090	1181	1174	1097	84	7-25-28	3520		Plugging to aband.—8-8-29
" " " " "	5	2479	1220	1259	1265	1214	45	9-7-28	121380		Prod. from Big Lake lime only Has prod. over million bbls.
" " " " "	6	2188	1040	1148	1130	1058	90	10-22-28	300		Prod. from Big Lake lime & bas. anh.
" " " " "	7	2412	1135	1277	1287	1125	152	6-10-29	15016	2293366	" " " " " " " "

Mid-Kansas-Transcontinental											
Yates "E" Lse.- Sec. 59	1	2301	1050	1251	1066	1235	16	11-28-27	200		Prod. from Big Lake lime only
" " " " "	2	2522	1225?	1297	1245	1277	20	8- -29		68,890	Prod. from Big Lake lime & bas. anh.
Yates "F" Lse.- Sec. 63	1	2481	1230	1251	1349	1132	119	3-10-28	5250		" " " " " " " "
" " " " "	2	2292	1092	1200	1206	1086	114	7-26-28	4832		" " " " " " " "
" " " " "	3	2334	1190	1144	1290	1044	100	9-12-28	14		" " " " " only
" " " " "	4	2229	1120	1109	1158	1071	38	11-12-28	80	280,128	" " " " " "
Yates "G" Lse.- Sec. 34½	1	2511	1245	1266	1379	1132	134	4-13-28	8522		Prod. from Big Lake lime & bas. anh.
" " " " "	2	2358	1210	1148	1288	1070	78	6-21-28	150		" " " " " " " "
" " " " "	3	2381	1100	1281	1277	1104	177	7-4-28	10076		" " " " " only
" " " " "	4	2389	1313	1076	1392	997	79	8-20-28	6	432,222	" " " " " "
Yates "H" Lse.- Sec. 32	1	2804	1620	1184	1706	1098	86	7-21-28	30		" " " " " "
" " " "	2	2928	1545	1383	1735	1193	190	8-5-28	43036		" " " " " "
" " " "	3	2876	1455	1421	1680	1196	225	9-5-28	26688		" " " " " "
" " " "	4	2783	1412	1371	1637	1146	225	9-17-28	26574		" " " " " "
" " " "	5	2836	1440	1396	1665	1171	225	9-29-28	27168		" " " " " & bas. anh.
" " " "	6	2934	1487	1447	1660	1274	173	9-16-28	66314		" " " " " only
" " " "	7	2919	1475	1444	1700	1219	225	12-11-28	14412		" " " " " "
" " " "	8	2863	1450	1403	1574	1279	124	3-11-29	40790		Prod. from Big Lake lime & bas. anh.
" " " "	9	2524	1310	1214	1381	1143	71	6-15-29	3996		" " " " " " " "
" " " "	10	2838								1,620,350	Drilling 1,335'—8-8-29
Yates "I" (R.C.S. Land)	1	2327	1260	1067	1325	1002	65	7-24-28			Dry hole

Mid-Kansas & Transcontinent'l											
Smith-Taylor - Sec. 33	1	2645	1175	1470	1354	1291	179	6-3-27	39336		Prod. from Big Lake lime only
" " "	2	2623	1213	1410	1459	1164	246	10-8-27	20752		" " " " " "
" " "	3	2745	1275	1470	1423	1322	148	11-19-27	4536		" " " " " "
" " "	4	2651	1230	1421	1400	1251	170	12-6-27	5606		" " " " " "
" " "	5	2574	1140	1434	1305	1269	165	12-13-27	8888		" " " " " "
" " "	6	2570	1145	1425	1229	1341	84	12-13-27	12404		" " " " " "
" " "	7	2716	1316	1400	1526	1190	210	2-20-28	6440		" " " " " "
" " "	8	2589	1180	1409	1368	1221	188	2-10-28	4234		" " " " " "
" " "	9	2658	1200	1458	1326	1332	126	4-19-28	14976		" " " " " "
" " "	10	2615	1250	1365	1465	1150	215	3-3-28	10320		" " " " " "
" " "	11	2645	1275	1370	1499	1146	224	3-9-28	14728		" " " " " "
" " "	12	2641	1260	1381	1484	1157	224	3-7-28	10492		" " " " " "
" " "	13	2562	1155	1407	1265	1297	110	3-28-28	46732		" " " " " "
" " "	14	2576	1170	1406	1350	1226	180	4-3-28	8050		" " " " " "
" " "	15	2715	1293	1422	1535	1180	242	6-14-28	37138		" " " " " "
" " "	16	2813	1410	1403	1635	1178	225	8-6-28	15558		" " " " " "
" " "	17	2827	1440	1387	1672	1155	232	8-21-28	5190		" " " " " "
" " "	18	2850	1500	1350	1725	1135	225	8-4-28	6734	2,216,738	" " " " " "
M. A. Smith Sec. 31	1	2461	1381	1080	1565	896	220	11-28-27			Dry hole—oil show
" " " "	2	2344	1160	1184	1245	1099	85	1-15-28	130		Prod. from Big Lake lime & bas. anh.
" " " "	3	2903	1510	1393	1735	1168	225	10-19-28	24466		" " " " " " " "
" " " "	4	2790	1455	1335	1651	1139	196	1-9-29	5784		" " " " " " " "

Mid-Kansas-Transcontinental											
M.A. Smith - Sec. 31	5	2549	1335	1214	1435	1114	100	3-29-29	1372		Prod. from Big Lake lime & bas. anh.
" " " "	6	2397	1230?	1167						311,416	Drilling—1,272'—8-8-29
Shell Petro. Corporation											
Tippett - Sec. 102	1	2621	1270	1351	1502	1119	232	10-12-27	7382		Prod. from Big Lake lime only
" " "	2	2656	1338	1318	1560	1096	222	11-23-27	2724		" " " " " "
" " "	3	2823	1477	1346	1703	1120	226	12-3-27	2040		" " " " " "
" " "	4	2569	1211	1358	1439	1130	228	12-22-27	7724		" " " " " "
" " "	5	2560	1215	1345	1425	1135	210	1-4-28	24286		" " " " " "
" " "	6	2549	1177	1372	1374	1175	197	1-17-28	44324		" " " " " "
" " "	7	2436	1105	1331	1330	1106	225	1-8-28	6876		" " " " " "
" " "	8	2557	1230	1327	1441	1116	211	7-29-28	10604		" " " " " "
" " "	9	2754	1397	1357	1622	1132	225	8-14-28	8510		" " " " " "
" " "	10	2666	1205	1361	1430	1136	225	10-4-28	8354		" " " " " "
" " "	11	2620	1253	1367	1477	1143	224	10-24-28	5892	1,575,960	" " " " " "
Smith "A" Lse. - Sec. 27	1	2671	1435	1236	1607	1064	172	10-12-27	1160		" " " " " "
" " " " "	2	2681	1430	1251	1618	1063	188	12-6-27	1252		" " " " " "
" " " " "	3	2836	1541	1295	1753	1083	212	1-16-28	1940		" " " " " "
" " " " "	4	2788	1505	1283	1724	1064	219	1-8-28	776		" " " " " "
" " " " "	5	2646	1400	1246	1582	1064	182	1-22-28	2954		" " " " " "
" " " " "	6	2666	1400	1266	1602	1064	202	7-13-28	408		" " " " " "
" " " " "	7	2733	1470	1263	1644	1089	174	7-3-28	1582		" " " " " "
" " " " "	8	2788	1542	1238	1724	1064	182	7-20-28	822		" " " " " "

Shell Petro. Corporation											
Smith "A" Lse. Sec. 27	9	2605	1355	1250	1551	1054	196	7-13-28	408		Prod. from Big Lake lime only
" " " " "	10	2646	1396	1250	(1568)	(1088)	(172)				" " " " " "
" " " " "	11	2619	1350	1269						559,504	Drilling—1,405'—8-8-29
Smith "B" Lse. Sec. 24	1	2922	1650	1272	1819	1103	169	5-22-28	1320	196,242	Prod. from Big Lake lime only Yates sand oil at 1,060-90'
Smith "D" Lse. Sec. 24	1	2938	1645	1293	1865	1073	220	8-2-28	2148		Prod. from Big Lake lime only
" " " " "	2	2961	1676	1285	1892	1069	216	10-16-28	2044		" " " " " "
" " " " "	3	2806	1623	1183	1738	1068	115	12-23-28	408		" " " " " "
" " " " "	4	2907								134,411	20 mil. gas 1,610-20'; Drilling—1,800'—8-8-29
Smith "E" Lse Sec. 2	1	2383	1206	1177	1330	1053	124	12-19-28	40	4,922	Prod. from Big Lake lime only
Simms Petroleum Co.											
Smith - Sec. 103	1	2589	1245	1344	1470	1119	225	9-25-27	54686		" " " " " "
" " "	2	2437	1130	1307	1246	1191	116	10-30-27	19052		" " " " " "
" " "	3	2440	1139	1301	1303	1137	164	11-28-28	32572		" " " " " "
" " "	4	2432	1150	1282	1253	1179	103	1-20-28	18846		" " " " " "
" " "	5	2483	1189	1294	1280	1203	91	1-22-28	85936		" " " " " "
" " "	6	2446	1120	1326	1275	1171	155	1-4-28	25914		Prod. from Big Lake lime & bas. ank.
" " "	7	2419	1125	1294	1266	1153	141	7-10-28	42918	2,721,980	" " " " " only
Simms Pet. Co. (Red Bank)											
Smith "A" Sec. 24	1	2709	1468	1241	1623	1086	155	8-19-27	782		" " " " " "
" " "	2	2753	1511	1242	1657	1096	146	11-25-27	782		" " " " " "
" " "	3	2799	1560	1239	1722	1077	162	5-10-28	392		" " " " " "
" " "	4	2697	1473	1224	1640	1051	167	10-1-28	318		" " " " " "
" " "	5	2924	1678	1246	1855	1069	177	12-19-28	390	240,105	" " " " " "

Grayburg O.Cc. (Allbright & Bell)											
River Bed	1	2150	1035	1115	1069	1081	34	6-29-27			Prod. from basal anhyd. & Big Lake lime
" "	2	2161	(1125)	(1036)	1509	652	384	8-15-27			Dry hole
" "	3	2154	(1054)	(1100)	936	1218	0	10-31-27			Prod. from basal anhyd.
" "	4	2154	(1060)	(1094)	1040	1114	0	11-20-27			" " " "
" "	5	2155	(1055)	(1100)	935	1220	0	1-6-28	400		" " " "
" "	8	2151	(1061)	(1090)	1095	1056	(34)	1-19-28			Prod. from Big Lake lime
" "	10	2151	1060?		1060	1091		2-12-28			" " " " " "
" "	11	2171	1833	338	2100	71	267	1-30-28			Dry hole
" "	12	2152	(1065)	1087	1100	1052	35	2-27-28		405,980[b]	Prod. from basal anhyd. & Big Lake lm. (b) includes 30,761 bbls. seepage
Phillips Pet. Co.											
Monroe - Sec. 39	1	2452	1225	1227	1380	1072	155	2-20-28	190	39,962	Prod. from Big Lake lime only
" " "	2	2495	1270	1225							Drilling—1,350'—8-8-29
Smith-Ramsey-Sec. 17	1	2821	1595	1226	1750	1071	155	3-2-29	3450		Prod. from Big Lake lime only
" " " "	2	2800	1600	1200	1720	1080	120	6-23-29	1434		" " " " " "
" " " "	3	2858								19,086	Drilling—974'—8-8-29
Phillips Pet. Co. (Matador)											
Smith - Sec. 24	1	2792	1548	1244	1708	1084	160	5-28-28	1470		Prod. from Big Lake lime only; oil show at 950-70'
" " "	2	2934	1647	1287	1860	1074	213	8-22-28	1170		Prod. from Big Lake lime only; oil show at 1,083'
" " "	3	2858								204,886	Drilling—815'—8-8-29
Mazda-Savoy Oil Co.											
Smith - Sec. 24	1	2695	1434	1261	1600	1095	166	10-20-27	584		Prod. from Big Lake lime only
" " "	2	2724	1483	1241	1642	1082	159	6-5-28	584		" " " " " "
" " "	3	2789	1530	1259	1705	1084	175	8-6-28	2586	249,645	" " " " " "

Cosby Oil Company											
Smith - Sec. 24	1	2735	1477	1258	1673	1062	196	10-7-28	600	73,640	Prod. from Big Lake lime only; oil in Yates sand—923-33'
" " "	2	2757									Fishing, 1,400'—8-8-29
Kirby Petroleum Corp											
Tippett - Sec. 40	1	2433	1238	1195	1383	1050	145	4-1-28	160	25,115	Prod. from Big Lake lime only; hole full oil from 500-523'
Kirby-Edson											
Tippett - Sec. 108	1	2545	1275	1270	1463	1082	188	11-29-27	500	120,121	Prod. from Big Lake lime only
Rio Pecos Oil Co.											
Yates - Sec. 543	1	2311	1630	681	1555	756	0	12-18-28			Dry hole
Skelly Oil Co.											
Tippett - Sec. 108	1	2630	1280	1250	1418	1112	138	3-28-28	180	47,942	Prod. from Big Lake lime only
Dixie Oil Co.											
Thompson - Sec. 72	1	2157	1085	1072	1130	1027	45	5-11-28	60	964	" " basal anhyd.
Greyburg Oil Co. Halff Lease - Sec. 70	1	2151			1052	1099	0	12-24-27	350		" " " "
" " " "	2	2153	1117	1036	1116	1037		3-24-28			" " " "
" " " "	3	2170	(1221)		1215		0	5-24-28		66,060	Dry hole

As indicated by the attitude of the Cretaceous beds (Fig. 6), the dome has a marked northwest-southeast elongation in the Big Lake lime (Fig. 7). Its configuration has also been affected in the southern part by the east-west regional line of folding across northern Pecos County, ordinarily referred to as the "Fort Stockton high."

The outer boundary of the oil pool in the Big Lake lime, or where edgewater prevails, on the northeastern flank of the dome, follows closely the 1,125-foot contour; on the western flank, the 1,200-foot contour; and on the southern flank, is at a slightly lower structural level, near the 1,100-foot contour. Its eastern limits have not yet been determined in Section 59 and in the area immediately south of Section 59 and west of Section 58, but it probably is limited there on the east by the 1,125-foot contour.

PRESENCE OF FAULT

An interesting fact brought out by both the cross section (Fig. 5) and the contour map (Fig. 7) is the presence of a pronounced fault between wells 12 and 13 (Fig. 5). This fault is seemingly normal in character, with the downthrow on the east side and with a total displacement of more than 360 feet in the Big Lake lime. This displacement seems to become gradually less, higher in the Permian beds (Fig. 5), and seems not to have affected the Triassic and Cretaceous strata. No oil or gas has been found in the field on the east side of this fault. This fault may have been a minor factor in the segregation of the rich accumulation of oil in the Big Lake lime immediately west of it.

OIL-PRODUCING ZONES

The oil is produced entirely from the Permian strata, although considerable oil has recently migrated into the Basement sands and Triassic which is thought not to have existed originally in these formations. Numerous showings of oil and gas have been encountered through the entire section of the Permian beds, but commercial production has, to this time, been confined to four zones. These are: (1) the Basement sands and Triassic or seepage oil zones; (2) the Yates sand; (3) the sandy phase at the base of the anhydrite; and (4) the Big Lake lime.

SEEPAGE OIL ZONES

In the east part of the field considerable oil has recently entered the Basement sands and the sands of the Triassic, the actual source of which is yet undetermined. This oil migrated down the dip and began to form seepages along the outcrop of the Basement sands and in alluvial gravels (Sec. 60, Blk. 1, I. & G. N. R. R. Co. Survey). This continued to such

an extent that efforts were made to save it by trenching, by drilling shallow wells, and by skimming the waters of Pecos River. On July 1, 1929, approximately 400,000 barrels of oil had been recovered by these methods.

YATES SAND

There are no producing wells in the Yates sand at this time, but many wells in the field have had substantial showings in this horizon and several wells have had sufficient oil to justify development of small areas. The enormous potential production of the Big Lake lime, however, makes it inadvisable to carry on operations to the Yates sand at this time. The enrichment of this sand occurs only in small irregular areas in the field. Probably the most important of these is in the southern part of the field, including parts of Secs. 23 and 24, Blk. 194. Other small areas occur in Sec. 60, Blk. 1, and in Sec. 104, Blk. 194, in the eastern and northern parts of the field.

SANDY DOLOMITIC PHASE IN ANHYDRITE

The sandy dolomitic phase at the base of the anhydrite presents a very substantial source of production. Although it is very irregular in its distribution, it is found in many parts of the field. Its greatest development is on the border of the field on the steep north and east flanks of the structure and along the exceptionally steep dip south of the east-west structural ridge in the southern part of the field. In the area of more gentle dip near the top of the structure and in the western and northwestern parts of the field it has its slightest development.

In the earlier stages of the drilling of the field, the Gulf Production Company's Thompson No. 1, drilled near Pecos River on the west end of Sec. 71, Blk. 1, International and Great Northern Survey, Crockett County, had an initial capacity of 450 barrels per hour in this horizon. This was an edge well, but it started operations in this locality which led to the development of approximately 80 acres, producing entirely from this sand. With the exception of a few scattered wells, this is the only area in the field with production from this sand alone. In other parts of the field where production was found in it, the wells were drilled into the Big Lake lime "pay" and are producing from both horizons. It is estimated that 52 of the wells of the pool belong to this latter class. The area in which paying production has been found in the sand has a very irregular distribution through nearly one-third of the producing area, or an area of approximately 5,000 acres.

A few wells of very large capacity have been obtained in the basal anhydrite zone, but most of them are small in yield when compared with

the enormous flow obtained if the limestone is penetrated. Under the column headed "Remarks," Table II, notations are made regarding all wells producing from this zone.

BIG LAKE LIME ZONE

The Big Lake lime pay zone is a continuous producing horizon throughout the entire field. This lime is probably a true marine limestone which has been altered to some extent by dolomitization. The uniformity of this dolomitization throughout a large area in the Permian basin leads to the belief that much magnesium carbonate was deposited in the original rock mass. As there is a shrinkage in volume of 12.3 per cent in the replacement of calcium carbonate by magnesium carbonate, it is probable that the processes leading to the porosity of the limestone commenced in the early stages of its deposition. After structural relief occurred, which brought the limestone into contact with surficial ground waters or with saline sea waters in which much magnesium carbonate must have been held in solution, this dolomitization continued with its consequent shrinkage and increase in porosity. Thus as the porosity from dolomitization increased, avenues for ground waters were formed, and the porosity of the limestone mass was further greatly increased by solution of calcium carbonates. These processes have reduced the rock to a honey-combed mass (Fig. 8) with a very high percentage of porosity. These interstitial pores vary from minute passages to cavities ½ inch in diameter.[1]

This excessive porosity seems to have been produced to a depth of several hundred feet into the limestone. No great decrease has been noticed to a depth of 225 feet in the many wells that have been drilled to that depth. There is every indication that it will continue to the general water-table of the field, which, in the central part of the pool, will permit a penetration of more than 375 feet of probable pay zone. Increased porosity in the eastern and northeastern parts of the field is indicated by wells of greater capacity in those areas. In this respect the pool is similar to the Big Lake pool, where the greatest porosity and acreage recovery are in the eastern part of the domal structure.

The source of the oil and gas in the Permian limestone is a debatable question, but the writers firmly believe that it is indigenous to that formation. The widespread distribution of oil in this zone and its uniform character throughout the area underlain by the formation are convinc-

[1]Frank R. Clark, chief geologist for Mid-Kansas Oil and Gas Company, concurs in this theory of the cause of the porosity of the Big Lake lime.

FIG. 8.—Fragment of Big Lake lime oil zone, approximately natural size, blown from bottom of hole (1,150 feet) of Mid-Kansas-Transcontinental's Yates "A" No. 1 well, showing porous character of pay zone. (By courtesy of Frank R. Clark.)

ing proof that its source was from life within the Permian sea and that it has not migrated into it from source beds at a greater depth.

OIL

PHYSICAL AND CHEMICAL CHARACTER OF THE OIL

Very complete analyses and tests of the oil from the Yates dome have been made recently at the Fort Worth refinery of the Transcontinental Oil Company. Concerning these, A. J. Slagter, general superintendent of refineries, makes the following statement.

> The crude from the Yates pool is classed by the Bureau of Mines as naphthene base, having a low cold test and viscosity, thus making the oil easily handled through pipe lines under all weather conditions.
>
> It produces 25% of gasoline by fractional distillation, but by cracking a total gasoline yield of 74.5% can be recovered. This gasoline would have an A. P. I. gravity of 55°, U. S. Motor gasoline with a very high "anti-knock" value (47% benzol equivalent).
>
> The fuel oil produced from this crude also has a very low cold test, flowing freely at zero temperature, which gives it an added value, especially in colder climates.
>
> Twenty-three (23%) per cent of low cold test (zero) 500 viscosity lubricating oil can also be produced from the Yates crude.
>
> Owing to the low cold test and the absence of paraffin, the objectionable salts and salt water settle more readily from the Pecos crude than from most of the paraffine base sulphur crudes. This is very important, as the magnesium and calcium salts are very corrosive. The samples of Pecos crude examined were practically free from these corrosive salts.

Both the physical and chemical character of the oil from the Big Lake lime zone, on the Yates dome, have been determined by the Bureau of Mines,[1] Washington, D. C. The results of this investigation are given in Table III.

PRODUCTION DATA

Table II shows the accumulated gross production for each lease to July 1, 1929. The grand total of accumulated production for the entire field, to that date, is 44,311,963 barrels. These figures merely represent the pipe-line outlet which has been allocated to each lease and to the field, and do not in the least represent capacity to produce. It is to be noticed that during most of the life of the field, the average production has been less than three per cent of the potential production. The daily potential for the field on July 1, 1929, was 4,590,686 barrels per day, and the pipe-line allocation was 130,000 barrels daily.

[1] "Analyses of Crude Oil from the West Texas District," *Report Serial No. 2849* (December, 1927), p. 18.

TABLE III*

ANALYSIS OF OIL, BIG LAKE LIME ZONE, YATES DOME

SAMPLE 27865

Texas, Yates Field, Pecos County

Composite sample
Sand-Permian lime.....Depth, 1,000-1,500 ft.
Specific gravity, 0.876.....A. P. I. gravity, 30.0°
Per cent sulphur, 1.61.....Per cent water, nil
Saybolt Universal viscosity at 70° F., 85 sec.....Pour point, below 5° F.
Saybolt Universal viscosity at 100° F., 59 sec.....Color, dark green

Distillation, Bureau of Mines Hempel Method

Air distillation — Barometer, 757 mm. — First drop, 28° C. (82° F.)

Temperature °C.	*Per cent cut*	*Sum per cent*	*Sp. gr. cut*	*°A.P.I. cut*	*Viscosity at 100° F.*	*Cloud test °F.*	*Temperature °F.*
Up to 50	0.4	0.4					Up to 122
50- 75	1.3	1.7					122-167
75-100	2.6	4.3	0.688	74.2	.....	.....	167-212
100-125	4.9	9.2	.736	60.8	.....	.....	212-257
125-150	3.9	13.1	.759	54.9	.....	.....	257-302
150-175	4.5	17.6	.779	50.1	.....	.....	302-347
175-200	4.6	22.2	.799	45.6	.....	.....	347-392
200-225	5.0	27.2	.820	41.1	.....	.....	392-437
225-250	6.5	33.7	.838	37.4	.....	.....	437-482
250-275	6.0	39.7	.854	34.2	.....	.....	482-527

Vacuum distillation at 40 mm.

Up to 200	4.1	4.1	.878	29.7	43	Below 5	Up to 392
200-225	6.0	10.1	.887	28.0	52	Below 5	392-437
225-250	5.8	15.9	.906	24.7	73	Below 5	437-482
250-275	5.0	20.9	.917	22.8	125	Below 5	482-527
275-300	11.9	32.8	.928	21.0	270	Below 5	527-572

Residuum, 25.7 per cent — Distillation loss, 1.8 per cent
Carbon residue of residuum, 11.6 per cent — Carbon residue of crude, 3.0 per cent

Approximate Summary

	Per cent	*Sp. gr.*	*°A.P.I.*	*Viscosity*
Light gasoline	4.3	0.688	74.2	.....
Total gasoline and naphtha	22.2	.753	56.4	.....
Kerosene distillate	5.0	.820	41.1	.....
Gas oil	18.5	.857	33.6	.....
Non-viscous lubricating distillate	9.8	.885-.912	28.4-23.7	50-100
Medium lubricating distillate	7.0	.912-.922	23.7-22.0	100-200
Viscous lubricating distillate	10.0	.922-.936	22.0-19.7	Above 200
Residuum	25.7	.984	12.3	.....
Distillation loss	1.8	.....	.....	.....

*Reports of Investigations, Bureau of Mines, Department of Commerce. 3606.

The potential production of the field for January 1, 1929, was 4,348,191 barrels per day from 284 wells. The figure of 4,590,686 barrels for July 1, 1929, was for 306 wells. It will readily be seen that the decline in the potential flow of the wells during this six months' period was very slight, although about 100,000 barrels of oil daily were taken from the field.

The greater porosity of the limestone in the eastern part of the field seems to be confined to the steeply dipping flanks on that side. In this respect it is similar to the Big Lake pool, where the greatest porosity exists on the steeper eastern flank. This greater porosity in the eastern part of the Yates pool is strikingly shown by the extremely high initial production of the wells. For purposes of comparison, the field was divided into an eastern and a western part in which an equal number of wells were producing on July 1, 1929. This division is shown by hachured lines on Figure 9. By using the official proration test figures for July 1, 1929, it was found that the average daily potential production per well for 153 wells in the eastern part of the field was 21,973 barrels, whereas the average for 153 wells in the western part of the field was 8,611 barrels. This shows an average flow of the wells in this eastern part to be 2.55 times that of the western, and indicates a proportionally greater porosity on this steep eastern flank. It is believed by the writers that this greater porosity on the more steeply dipping parts of the anticline will apply to other anticlinal structures in the Permian basin and may be an assistance in locating pools on some folds where porosity is of prime importance.

ESTIMATE OF ULTIMATE OIL RECOVERY

As the field has developed, the growing realization of the importance of several factors in regard to it has led to greatly increased estimates of the ultimate yield of the pool. These factors are: (1) exceedingly great porosity of the limestone and the continuity of this porosity throughout the area of the pool as well as at greater depths in the limestone; (2) great thickness of pay zone which probably reaches a maximum of more than 375 feet in the central part of the field; (3) a low gas-oil ratio which is being maintained by careful drilling and by back pressure on the wells; and (4) hydrostatic pressure (approximately 700 pounds to the square inch) which helps flow many of the wells and which is likewise being controlled and will be a great factor in bringing about a high percentage of recovery if its control is continued.

Because of the irregular cavernous condition of the Big Lake lime, tests do not give an accurate idea of its percentage of porosity. Frag-

ments of it blown from wells show channeling that has been produced by ground waters, and it can be stated without much opposition that this condition has produced a porosity much greater than that of average oil sands. The degree to which these channels through the limestone have developed is strikingly shown by the amount of oil which they give up in the one-hour flow tests. Although the porosity is greater in the eastern and northeastern parts of the field, there is a high percentage of porosity in the entire producing area. As the wells in the central part of the pool have been deepened to the permitted 225 feet into the Big Lake lime, it has been found that there is but little decrease in porosity with depth. It is highly probable that many of these wells can be deepened farther and penetrate much more pay horizon before reaching the water-table, and thus increase the flowing life of the wells.

As there has been an almost complete separation of the oil and water in the field, the water-table maintains a practically uniform level. It is thought that the greater part of the Big Lake lime above the water-table will be productive. The highest structural elevation on the top of the lime yet drilled is 1,476 feet above sea-level. The water-table maintains a fairly uniform level between 1,060 and 1,090 feet above sea-level. This should give a maximum thickness of "pay" of more than 375 feet in the structurally higher parts of the field. This thickness of "pay" should gradually thin toward the edges of the pool. By a system of zoning and computation of the thicknesses at different structural elevations, it was found that the average thickness of pay limestone above the water-table, for the entire field, is approximately 130 feet.

Most of the wells in the field, especially those in the structurally high areas, have had sufficient gas with the oil to flow the wells steadily. Many of these wells have had a very heavy flow of gas. By consistent application of back pressure on these wells, the volume of gas produced per barrel of oil has been greatly decreased, thus conserving the gas in the "pay" to produce a very much higher efficiency not only in decreasing lifting costs, but also adding much to the ultimate recovery from the leases.

There is little doubt that the great flowing capacity of the wells in the field is aided very materially by the hydrostatic pressure exerted from below. This water, which maintains a constant level below the oil, would be a source of great danger if the wells were permitted to maintain an open flow through any great period of time. It would cause water-coning up through the extremely porous limestone, and practically

all wells permitted to maintain such open flow would eventually produce more water than oil. The steady back pressure which is being maintained will prevent this water-coning and allow this bottom water to continue to exert its flowing pressure, and this should be an important factor in bringing about a greater ultimate recovery. It is believed that the pool is capable of producing several times its present pipe-line outlet without endangering the ultimate oil recovery from the wells.

The field has not yet reached that stage of development where accurate estimates of the ultimate recovery can be made, and there are no fields in the Permian basin of sufficient age for satisfactory comparison in estimating the recovery. Careful estimates, made by the senior writer,[1] of the recovery from a fully developed 460-acre tract in the eastern part of the Big Lake field of Reagan County, where the Texon zone is very porous, give an ultimate recovery of 35,000 barrels per acre. This is from an average pay zone 23 feet in thickness. With a much higher percentage of porosity in the pay zone on the Yates dome, its greater thickness of saturated "pay," and the extremely favorable methods of operation in effect in the Yates field, it is felt that an estimate of 40,000 barrels per acre recovery, throughout the area of the pool, is conservative. This estimate of 40,000 barrels for the approximate 16,000 acres (determined by planimeter from the map from which Figure 7 was reduced) of productive area in the field, gives an estimated total ultimate recovery of 640,000,000 barrels. An even higher estimate than this is tenable, and an ultimate recovery of 800,000,000 barrels is not an improbability.

GAS

Although there is not an excessive amount of gas in the pay formations, there is ordinarily a sufficient amount to flow the wells freely. On the higher parts of the structure, wells have been drilled which gauged as high as 60,000,000 cubic feet per day.

This gas is of the ordinary sulphur type found in all of the limestone pools of the Permian basin. The gasoline content varies in different parts of the pool and in the individual wells, depending on the pressures exerted on these wells. The general average gasoline content for the pool is about 1.25 gallons per 1,000 cubic feet. It is thought that in the later stages of the field this content will be much greater. One casinghead gasoline plant is now under construction in the field.

[1]Ray V. Hennen, *op. cit.*

PRESENCE OF WATER

Wells which have encountered water in the Big Lake lime have been almost entirely confined to the edges of the pool, where these wells were drilled to the general water-table level. It is estimated that about 30 wells of this type have obtained edge-water. This water varies in amount from a trace to flowing wells. As has been stated, this water-table maintains a fairly constant level of 1,060-1,090 feet above sea-level.

Water contained in the sandy phase of the anhydrite has reached higher elevations than this water level in the Big Lake lime, and, in those parts of the field where the sandy phase is best developed, higher water is encountered. This higher water has also permeated the limestone in these localities and brought about locally higher elevations in the water-table in the formation.

DRILLING AND PRODUCING METHODS

Practically all the wells of the field were drilled by the cable-tool method, the rotary being found impractical. Although some of the companies are using standard derricks and equipment, many of the wells, because of their shallow depth, are drilled with National machines. These machines are moved from the wells when they are completed, leaving only the ordinary casinghead hook-up with battery of flow tanks as evidence of a producer, which is generally of large capacity. This lack of derricks and physical evidence of activity, prevailing in most fields, is commented on by many visitors to the pool.

CASING METHODS

Three strings of casing are ordinarily used in drilling and completing a well. The first (10-inch or 12½-inch) is set through the fresh-water horizons of the Basement sands and the Triassic; the intermediate (8¼-inch or 10-inch) through the soft red-bed series to the anhydrite; and the last (6⅝-inch or 8¼-inch) is set on top of the first pay zone.

PRORATION METHODS IN EFFECT

Figure 9 shows the division of the field into tracts or units approximating 100 acres each. This division was resorted to by the operators, with the approval of the State Railroad Commission, for the purpose of making an equitable distribution of production over the area of the pool. The production or pipe-line allocation allowed each unit is based on both the potential flow of the wells on the unit and on the amount of acreage. Each well is given a one-hour flow test, generally monthly, and 75 per cent of the pipe-line outlet of the pool is based on this poten-

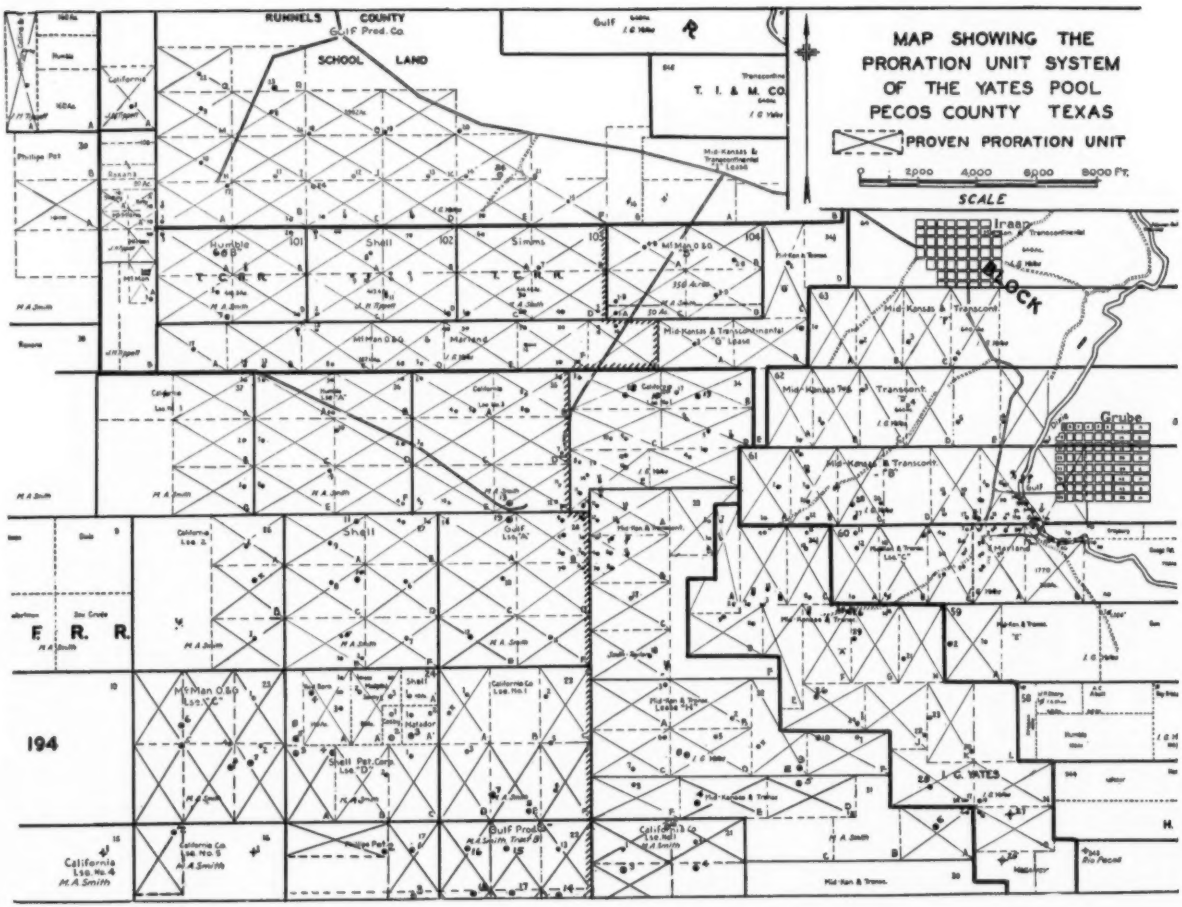

FIG. 9.—Map showing proration unit system in effect at Yates pool.

tial flow. The participation of each unit in this 75 per cent is based on the average flow of all wells on the unit. The other 25 per cent is based on the acreage held and each unit is assigned a specified amount of this outlet.

This plan has led to a very desirable distribution of the wells in the area of the pool and tends to remove the incentive toward the drilling of additional wells. The result has been a cessation of drilling except on the edges of the pool, where operators are making a few attempts to extend the pool and bring additional units into the producing class, so that they may participate in the distribution of the pipe-line outlet. This outlet allocated each unit is ordinarily only a very small percentage of the potential production of the wells on the unit, and this necessitates a pinching of wells to such an extent that they are producing through an aperture only a fraction of an inch in diameter.

BOTTOM-HOLE PRESSURE TESTS

Tests made indicate that the original bottom-hole pressure of the wells, when they are drilled in, is approximately 700 pounds to the square inch. This pressure, which decreases when the wells are opened, builds up readily to about this figure when back pressure at the well head is applied.

FUTURE DEVELOPMENTS

Within the proved area of the pool there are about 1,300 undrilled locations. The 306 wells producing on July 1, 1929, represent less than 20 per cent of the drilling necessary completely to develop the pool. This development will probably be carried on through a long period of time.

Because of the attitude of the operators, there is little likelihood of deeper tests being made on the Yates anticline in the near future. However, when such tests are justified by conditions in the oil industry, they will be highly interesting projects.

In the pools of Winkler and Howard counties, pay zones have been encountered as deep as 800 feet in the "Big lime." It is the general impression that below this penetration into the limestone it is barren. However, this view is not supported by thorough drilling, especially in the Pecos County area, where very little is now known regarding conditions in the lower part of the Permian beds. It is believed that other porous zones occur in the Permian limestones, which may afford production. This will be largely dependent on whether source material occurs within this lower limestone mass.

The deeper stratum below the Permian, in which production has been obtained by the Texon Oil and Land Company's University No. 1-B well in the Big Lake field at a depth of 8,520 feet, will form an objective in the Yates area which should offer possibilities of high-gravity oil.

In view of the fact that the Yates dome lies between this Big Lake pool and the outcrop of Pennsylvanian and older beds in the Marathon uplift where they contain sands and bituminous shales, it is believed that production in these deeper zones is highly probable.

FIG. 10.—Mid-Kansas-Transcontinental Yates "*A*" 30 flowing 10-inch stream of oil 200 feet high from depth of 1,070 feet. Official proration test of this well on September 23, 1929, gave it 8,528.4 barrels of oil an hour, or a daily potential of 204,681 barrels—the largest actually gauged production ever found for any well.

GEOLOGICAL NOTES

VAN FIELD, VAN ZANDT COUNTY, TEXAS

The Pure Oil Company's Jarman No. 1, the discovery well in the Van field, is located near the town of Van in the southeastern part of Van Zandt County, Texas. It is 55 miles northeast of the Powell field in Navarro County and 45 miles west of north from Boggy Creek field in Cherokee and Anderson counties.

In the early part of 1927, the geological department of The Pure Oil Company was making a careful investigation of East Texas for surface indications of deeply buried salt domes. In the course of this work, the topography, drainage, erratic dips, and surface faulting in the southeastern part of Van Zandt County suggested an uplift with its highest point in the vicinity of the town of Van. In May, 1927, a seismograph party of the Geophysical Research Corporation in the employ of The Pure Oil Company was assigned to detail this area. Their work indicated a large anticline, the apex of which seemed to be just north of Van. The following mention of this discovery was made[1] at the New York meeting of the American Institute of Mining and Metallurgical Engineers in February, 1928.

VAN PROSPECT

Location.—Van Zandt County, at the town of Van.

Date of Discovery.—May, 1927, by a seismograph party of the Geophysical Research Corpn., in the employ of The Pure Oil Company.

Depth to Salt.—No salt records were obtained at this prospect, but there is definite uplift which has been isolated. Its character from seismograph work appears similar to the uplift at Troupe, and its location in respect to regional structural features in East Texas suggests a deeply buried dome.

Development.—There has been no drilling on this prospect.

Subsequent to the seismograph work, a detailed survey of the areal and structural geology of this region was made and it indicated that the Wilcox-Claiborne (Eocene Tertiary) contact had an abnormal trend east and south of Van. From the vicinity of Jamestown a greensand near the base of the Mount Selman formation occurs intermittently

[1]R. A. Liddle, "Petroleum Development in East Texas and along the Balcones Fault Zone, 1927," *Amer. Inst. Min. Met. Eng., Petrol. Div., Petroleum Development and Technology in 1927* (New York, 1928).

southward along the Smith-Van Zandt County line to the locality of Galena. Turning southwest at this place, it strikes due west approximately 3 miles, forming a rim around the east and south flanks of the structure. Structural contours on this greensand show a fairly steep dip toward the east, southeast, and south; on the west and north flanks of the Van structure the greensand has not been preserved.

In January, 1929, core drilling was begun on the Van structure, the locations for the tests being governed by the control established from the geological and geophysical work. Core drilling was completed in July, 1929. In some of the core holes on top of the dome, oil and gas at shallow depths were encountered, the best showings being in the Nacatoch sand (Upper Cretaceous) which lies between depths of 1,100 and 1,300 feet. The coring confirmed earlier geological and geophysical work in indicating a domed anticline of great magnitude. Jarman No. 1 encountered many showings of oil and was completed as a commercial well in the Woodbine formation (Upper Cretaceous) at a depth of 2,710 feet on October 13, 1929.

At 2,587 feet, 9⅝-inch casing was set. To date no flow string has been run and the well has not been swabbed or bailed, as is customary in other fields where production is from the Woodbine. After being washed the well had an initial production of 147 barrels an hour. For the first 24 hours it flowed 1,790 barrels through a 1½-inch choke. Then it was gradually pinched and on October 20 was placed on ½-inch choke. Since that time it has flowed at an average rate of 260 barrels a day on ½-inch choke. The gravity of the oil is 35.4° A. P. I., and in content it is similar to the oil of the Powell field.

The top of the Woodbine formation in Jarman No. 1 is placed at approximately 2,560 feet, where the first red shales occur below fossiliferous beds of the Eagle Ford formation. A record of the Woodbine thus far penetrated in Jarman No. 1 is:

Feet	
2,560-2,610	Red and gray mottled shale. Green and black shale
2,610-2,636	Sand with thin beds of sandy shale, all of which is saturated with oil. (Gas sand, hard, 2,610-2,613)
2,638-2,655	Red and gray mottled shale
2,655-2,662	Oil sand, highly saturated
2,662-2,678	Red and gray mottled shale
2,678-2,710	Oil sand, alternating soft and hard beds. (Gas sand, hard, 2,678-2,680.) At 2,710 the well is still in highly saturated oil sand

R. A. Liddle

The Pure Oil Company
Fort Worth, Texas
November 4, 1929

ON SPECIFYING THE TYPE OF SUBSURFACE STRUCTURAL CONTOURING

During the past few years the average oil company executive has been learning the meaning and interpretation of structural contour maps. He recognizes an anticline, a syncline, or a dome as these are represented on a map, and he knows the favorable areas where leases should be taken. He does not, however, ordinarily understand just how such maps are constructed, and, as there are several methods, each leading to a different picture, an explanation seems to be needed.

It often happens that a consulting geologist submits a map showing a certain structure, and when the executive attempts to check this structure with the same structure as mapped by his own organization, he finds considerable difference. The chief geologist is called in and must explain that different methods of contouring were used but that the same interpretation of structure may be made from both maps by studying the control.

So far as the writer is aware, the various types of contouring have never been named. They might be classed as follows.

1. *Mechanically spaced contouring.*—Contouring based on mechanical or mathematical spacing is ordinarily very conservative and is entirely mechanical. If correctly done, the imagination and bias of the author are completely eliminated (Fig. 1).

2. *Parallel contouring.*—In parallel contouring, the contours are drawn as nearly parallel with one another as possible, although the spacing is variable. This type of contouring is less conservative than mathematical spacing and has a tendency to indicate structures where otherwise merely a flattening in dip might be shown. Such structures tend to die out if extended into the unknown (Fig. 2).

3. *Equi-spaced (equi-dip) contouring.*—In this type of contouring the contours are spaced equal distances apart, the distance being determined by the dip between two relatively close control points or by a previously determined regional dip. The dip or spacing used is ordinarily the steepest or smallest found in the area being mapped. This method is the most radical of all and leads to considerable inference regarding possible or probable structures. Instead of contouring flat dip areas as such, reversals and structures are mapped (Fig 3).

The type, or combination of types, of contouring used by different geologists is largely determined by the geologist's ideas of the region and by personal or other influences. Oil companies usually prefer to use a conservative or semi-conservative type of contouring, whereas a

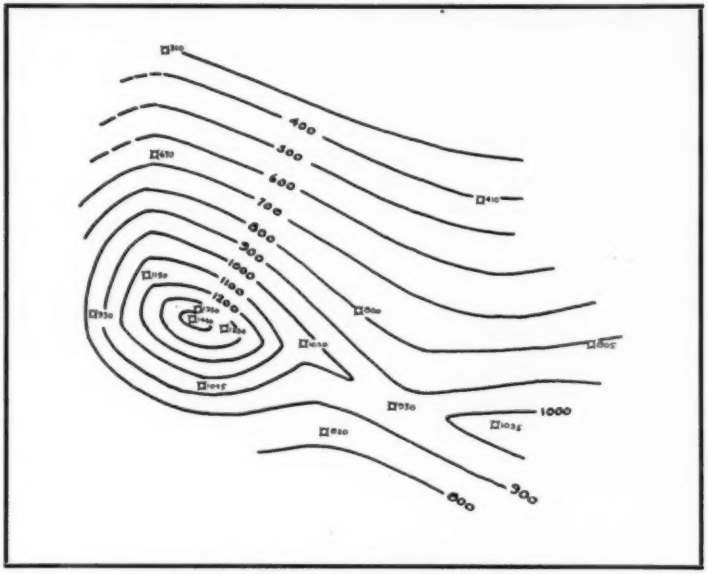

FIG. 1.—Mechanically spaced contouring.

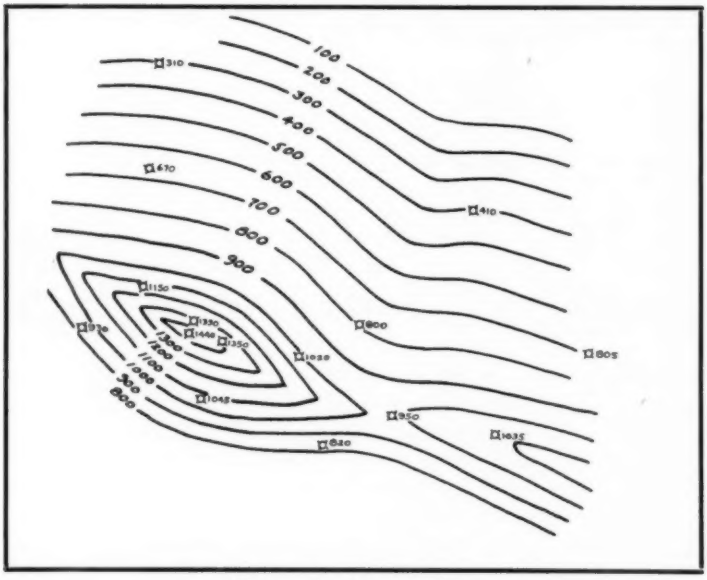

FIG. 2.—Parallel contouring.

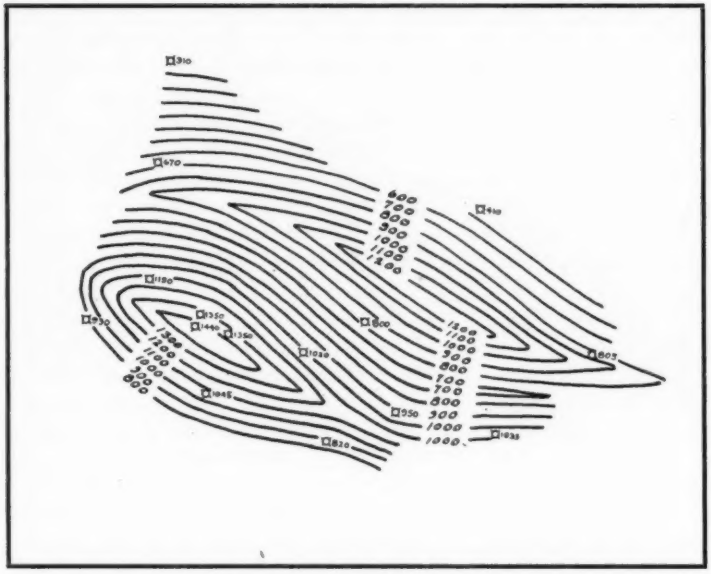

FIG. 3.—Equi-spaced contouring.

geologist interested in putting across a deal on a certain tract may employ the most radical.

It is not possible to state which method or combination of methods is the best to use, since no one type is correct to the exclusion of the others. It is for this reason that executives should understand the geologist's position and should be able to evaluate subsurface maps regardless of the type of contouring used. It is suggested that subsurface maps be labelled so as to designate which type or combination of types is used.

R. E. RETTGER

SAN ANGELO, TEXAS
October 22, 1929

LONG SHOTS WITH AN ALIDADE

While operating an alidade to obtain well elevations in southern Oklahoma and northern Texas several years ago, the writer found the heavy growth of blackjack oak an obstacle which made progress slow.

Long level shots were tried with the discovery that under proper conditions, errors in elevation did not exceed 2 feet in distances as great as 40,000 feet. The following examples indicate the accuracy as well as the time saved.

1. By a traverse that began and finished on a well of known elevation, the elevations of three other wells were obtained. These ranged from 18,000 to 30,000 feet apart. The work was done in half a day and the traverse closed with 0.6 foot error.

2. On another occasion, during cold weather and overcast skies, two instrument stations were established on the crest of hills where two level shots were made to obtain the elevations of two wells, one 38,000 feet away and the other 40,000. The first required a top-hair reading and the second a bottom-hair, but by subsequent short-shot traverses to other closer benchmarks, both of these long shots were found to be less than 2 feet in error. From 20 to 30 minutes were required for each determination, but the short-shot check traverses required several hours.

3. In 20 minutes, from a single instrument station, the elevations of four wildcat wells from 20,000 to 30,000 feet away were determined with less than 2 feet error. These shots were also checked by short-shot traverses to less distant benchmarks.

4. A last example is that of a well 15 miles from the nearest benchmark. This traverse required four instrument stations and consumed 2 hours' time.

The accuracy of the long shots is known from their close agreement with the results obtained by short-shot, but more time-consuming traverses to closer benchmarks which did not afford the proper conditions for long level shots. Or in some cases two or three long shots from different points agreed so closely that the accuracy could not be doubted.

The great saving in time makes worth while a description of the precautions used to insure accuracy. The level bubble was in perfect adjustment before each long shot. The instrument station was so selected near a benchmark that the line of sight from either the top, middle, or bottom cross hair intercepted the derrick to be determined. The position of the hair in reference to the girts was recorded in a notebook by drawing a sketch of the derrick from its crown block to the girt below the cross hair. This position could be estimated within a foot.

After making the reading, the derrick was examined at close range in order to complete the picture in the notebook which then showed the girts from the crownblock to the derrick floor and the position of the cross hair on or between them. Its height above the floor was then

entered under "Rod reading" in the notebook and after making the usual correction for curvature and refraction, the elevation could be computed. The formula 0.02 times the number of thousands of feet squared was used to determine this quantity, which amounts to 32 feet in the case of a 40,000-foot shot. The only other correction necessary is in situations in which the middle hair does not pass through the center of the axis of rotation. An average reading of the normal and inverted positions must then be used.

It is always preferable to select an instrument station from which a level shot may be taken with the middle hair, but this is not always possible. When it is used, an approximate determination of the distance suffices for the calculation of curvature and refraction, as even a 1,000-foot error makes a negligible mistake in the elevation.

But when the top or bottom hair is used in a level shot, great accuracy is needed in the determination of the distance. The following example will illustrate the necessity for this. The elevation to be obtained is that of a derrick 30,000 feet from the instrument station. With the alidade level, the line of sight from the bottom hair is an estimated distance of 3 feet below the sixth girt below the crownblock. A sketch showing this relation is made in the notebook. Later examination at close range makes possible the completion of the sketch. Below the crownblock there are 12 girts 8 feet apart and below the lowest there is an interval of 12 feet to the derrick floor. Under "Rod reading" is then entered 57*B*, indicating that the bottom hair intercepted the derrick 57 feet above the floor.

The next part of the problem is to determine the distance between the instrument station and the derrick in order to change the bottom-hair to a middle-hair reading and also to compute the correction for curvature and refraction. This could be quickly done if the instrument were closer to the derrick, by counting the number of girts and fractions thereof between the top and bottom hairs.

But to do this at 30,000 feet would necessitate a derrick 300 feet high. Instead, a quarter hair is used to obtain a quarter-stadia interval in terms of girts spanned, which can then be multiplied by 3,200 to obtain the distance. A glance through the alidade shows that even this is not possible in the present case. A quarter-stadia interval at 30,000 feet is 75 feet.

Fifty-six feet is all that may be used of the derrick for measurement, as, due to obstructions, only the upper eight girts are visible. The only alternative is to use the gradienter. It is rotated through

18.66 divisions in order to make the middle hair move from the lowest visible girt to the highest. This result is obtained by averaging three readings with the telescope in normal position and three with it rotated 180°.

The value 18.66 is to the number of divisions required to move the middle hair one stadia interval as 56 is to the stadia interval. It is customary to assume that turning the gradienter one revolution, or 100 divisions, will move the middle hair the amount of one stadia interval. Such an approximation will not do; the amount changes and must be determined anew each time a distance calculation is made.

Rotating the gradienter clockwise until the top hair coincides with a girt about half way between the highest and lowest of those used to get the value 18.66, the reading is noted. Additional clockwise rotation makes the bottom hair coincide with the same girt, indicating that the middle hair has been elevated through the value of one stadia interval. The reading is again noted. It is the same as the first, showing that for this particular set-up, turning the gradienter through 100 divisions causes the line of sight from the middle hair to move vertically one stadia interval. The operation is repeated so that an average may be taken of six readings to give the result, 100. Three readings will suffice if very close agreement is obtained. The distance may then be computed by the equation 18.66 is to 100 as 56 is to the stadia interval, which gives 300 feet, or 30,000 feet for the distance.

There must be extreme accuracy in the determination of the quantities 18.66 and 100. If 18 were read rather than 18.66, the distance to the well would be calculated as 31,100 feet, a 1,100-foot excess. This would make the determination of the elevation of the well 5.5 feet too low. But if an average is taken of six careful readings the result will not be 18 but 18.66, which will give the correct distance and elevation.

In obtaining the value 18.66, it is best to use the middle hair. The readings of the top, middle, and bottom hairs differ from one another by small amounts. These discrepancies are due to the changing value of the gradienter divisions. When the axis clamp arm reaches its maximum inclination either away from or toward the gradienter, as many as 150 divisions or 1½ turns are required to make the middle hair move up or down one stadia interval.

But in the vertical position only 100 divisions or one revolution is required. The explanation of this lies in the changing relation of the gradienter screw and the axis clamp arm. When the latter is vertical, the gradienter screw is at right angles to it; therefore its movement is

entirely spent in displacing the axis clamp arm. But when the arm is inclined either away from or toward the gradienter, the screw is pressing against it at an oblique angle so that more turning is required to produce a given displacement of the axis clamp arm. Each division, as the arm becomes more inclined, represents a smaller fraction of a stadia interval.

In the vertical position, one division on the gradienter represents 1/100th of a stadia interval. In the position of maximum inclination, one division represents only 1/150th of a stadia interval. As there are 40 stadia intervals on the Beaman arc within the span of these two positions, there is a change of about 1/10,000th of a stadia interval per division. This relation is also changing, but this figure will represent it approximately.

How this affects the readings can be best explained by continuing with the example already given. With the middle hair on the lowest visible girt, the gradienter reads 50. When turned clockwise to make the middle hair coincide with the top girt, it reads 68.66. To obtain the average value of the divisions between 50 and 68.66 in terms of a stadia interval, the gradienter is rotated counter-clockwise until the top hair is on a girt midway between the highest and lowest of those visible, in which position the reading is 9. It is then rotated clockwise until the bottom hair is on the same girt, in which position it reads 109, showing that 100 divisions represent one stadia interval when the gradienter screw is rotating between 9 and 109. This indicates that the value of the division between 59 and 60 is exactly 1/100th of a stadia interval. Those below 59 represent 1/99.99, 1/99.98, et cetera, and those above 60 represent 1/101.01, 1/102, et cetera, of a stadia interval. But when an average is taken of the divisions for an equal distance on both sides of division 59, the result is 1/100th of a stadia interval per division. The divisions between 50 and 68.66 lie equally divided on both sides of 59; therefore when an average is taken they will represent 1/100th of a stadia interval per division.

That is why the preceding method gives accuracy in spite of the changing value of the gradienter divisions. If the bottom hair is used to get the number of divisions corresponding with the distance between the highest and lowest girts exposed, the gradienter will read 100 with it on the lowest girt and 118.8 with it on the highest girt, making the distance equivalent to 18.8 divisions rather than 18.66. This is because the divisions between 100 and 118 represent intervals showing lesser fractions of a stadia than those between 50 and 68.66 and so more of them are required to turn up a given part of a stadia interval.

Their average value must be determined before the value 18.8 can have any significance. Rotating the gradienter counter-clockwise past 59 and then clockwise to 59 to take up the slack, the position of the top hair is noted. The clockwise rotation is then continued until the bottom hair coincides with the position formerly occupied by the top hair at the reading 59. The reading is now 160, showing that 101 divisions equal a stadia interval in the span between 59 and 160; 109 is the mid-point of this span and the value of this division is 1/101 of a stadia interval. The divisions between 100 and 118.8 lie equally distributed on both sides of 109; therefore their average will be 1/101 of a stadia interval each. The ratio, 18.8 is to 56 as 101 is to the stadia interval, gives 300, as before, when the quantities 18.66 and 100 were used. Still different values would be obtained by using the bottom hair, but they would give the same result, 300 feet for the stadia interval.

The reason for using the middle hair is that the derrick suffices for both readings, but if a bottom-hair reading is made at 30,000 feet under the circumstances of the example given, points of reference above the derrick would be required for part of the reading and vice versa for the top hair.

Now that the distance to the derrick has been determined as 30,000 feet, the remainder of the problem can be worked. Knowing that a half stadia interval is 150 feet, the bottom-hair reading can be converted to a middle-hair reading by adding 150 to 57. The elevation of the planetable is 1,000 feet. The elevation of the derrick floor is 793 plus the correction for curvature and refraction. This amounts to 18 feet, which gives 811 as the elevation of the derrick floor.

When the alidade is moved to sight in another direction the calculations must be repeated, as nine times out of ten a different part of the gradienter scale will be used, the divisions of which will have a different value.

If the procedure as here outlined is followed in every case, the result will be accurate within 2 feet, which compares well with any traverse made by an alidade using short shots and a stadia rod. The latter method might require half a day or even more if the line of the traverse is heavily timbered, whereas the former requires 20 minutes. As there are fewer calculations, there is less likelihood of error. Another advantage is the saving of time when on a later occasion it is desired to use the same derrick for a benchmark. The instrument man may set up anywhere within 6 miles of it, provided one of the cross hairs intercepts it when the alidade is level, and begin his traverse from that point rather than

from the well. Having a sketch of the derrick with its specifications recorded in his previous notes, it is not necessary for him to make a close inspection of it, and thus the time that would be consumed by 6 miles of driving followed by 6 miles of traverse, is saved.

The example given introduces all of the most unfavorable conditions which tend to interfere with accuracy. In example 4, the 15-mile traverse was accomplished in two hours by using a water tank at one end and a derrick at the other. The water tank was 600 feet from a benchmark. Using this distance as the base of a right triangle, the angles to prominent points on the tank were measured and the elevations determined by the tangent equation and recorded in a sketch.

The first instrument station was established on a hill about 35,000 feet from the tank. It was so selected that the middle hair coincided with the top of the tank. Three trial set-ups were required to find such a place. In order to make the 26-foot correction for curvature and refraction, the distance was determined by the use of the gradienter and the known distance between the top and bottom of the tank. A traverse to the summit of a hill was then made with the ordinary stadia rod. From there it was possible to see the derrick; thus a level shot was made to complete the work.

Nothing has been said about long-distance angle shots. Several experiments proved them to be too unreliable, whereas the long-distance level shots were found to be consistently accurate.

DONUIL HILLIS

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LOS ANGELES, CALIFORNIA
November, 1929

DISCUSSION

TEMPERATURE GRADIENT IN PECHELBRONN, ALSACE

The valuable article by Haas and Hoffmann on "Temperature Gradient in Pechelbronn Oil-Bearing Region, Lower Alsace: Its Determination and Relation to Oil Reserves" in the October *Bulletin* is suggestive and reminds me of an old paper by Andrae on the structure of the Rhine Valley, and of Butler's recent speculations on the Dead Sea and Jordan trough. To explain the fact that the geotherms are nearer the surface with increasing distance from the Rhine Valley fault, Haas and Hoffmann make the suggestion that this is due to a change in the diffusivity or conductivity of the rocks. This is certainly a factor, but in order to have "multiple working hypotheses" I would also suggest that, as the beds are coarser toward the west and become finer toward the east, there was probably an initial dip in an easterly direction. Now the result of the normal faults shown in their section is to keep the same horizon approximately on the level. A line originally horizontal when these beds were laid down would therefore be arched up by the faulting, and it may be that this arching has crowded the isotherms toward the surface while the surface itself has been eroded so as to be kept at a practically horizontal level. Not only that, but such an upward faulting of the underlying beds might tend to bring toward the surface beds which had at one time lain deeper and been more compacted and were therefore more conductive. This would apply also to any basement of very old rocks which might underlie the Mesozoic beds. These factors would combine in bringing the isotherms near the surface.

These suggestions do not at all discredit the valuable conclusion of the authors that the isotherms do not show anything important regarding the distribution of oil. There is one other feature of the cross sections to which more attention might be called. That is, that if the surface temperature is 10°, the rate of increase is much slower near the surface than from 20° to 50° and is in several sections more rapid from 30° to 40° than from 20° to 30°. This is what has been found in many other places, and is an effect which I have attributed to a recent amelioration of the surface climate. I would also call attention to the fact that it is quite unsafe to figure the geothermic gradient from the air temperature. Observations have shown that the average temperature of the soil a few inches or feet down may vary from 0.5° to 4° from the average temperature of the air. This may be due to a blanketing effect of snow, but may also depend on the color of soil. Van Orstrand has a mass of data on this subject. The uncertainty thus introduced will, however, hardly affect the statement that the rate of increase from 30° to 40° is considerably more rapid than that at the surface.

ALFRED C. LANE

TUFTS COLLEGE
BOSTON, MASSACHUSETTS
October 21, 1929

CORRECTION
CONTROL AND ADJUSTMENT OF SURVEYS WITH THE MAGNETOMETER OR THE TORSION BALANCE

The necessity for the following corrections in my paper on "Control and Adjustment of Surveys with the Magnetometer or the Torsion Balance" in the September *Bulletin* has been called to my attention by E. E. Gundermann.

Page 1,173: normal equations (4), $2X3$ should read 2×3; the minus sign should be changed to *plus* for d, $2 \times 3Y$, and $2(b\text{-}c\text{-}f)$.

Pages 1,171 and 1,173: for W read Z; for Y read W, and for Z read Y.

Page 1,176. Figure 4: reverse the arrows of d, e, and f.

Figure 5: X_3 and X_4 of the figure should be interchanged.

DONALD C. BARTON

HOUSTON, TEXAS
November 25, 1929

REVIEWS AND NEW PUBLICATIONS

Applied Geophysics in the Search for Minerals. By A. S. Eve and D. A. Keyes. Cambridge University Press (1929). 253 pp., 92 text figs.

This textbook comprises the following chapters: Introduction; Magnetic Methods of Ore Detection; Electrical Methods; Electro-Magnetic Methods; Gravitational Methods and the Torsion Balance; Seismic Methods; Radioactive and Other Methods,—the "other methods" comprising geothermal methods, micro-paleontology, penetration of radio waves, salt domes, geophysical exploration in Australia, brief notes on diamond drilling, laboratory experiments, searching for underground pipes, comparison of surveys over the same area by different companies; Appendices; Wenner's Formula, Analogy between Capacitance and Resistance; Bibliography of 64 titles. The instruments and methods are described in moderate but not too much detail, and the explanations are illustrated by the results of actual surveys.

This pleasing little textbook should find a wide place for itself, particularly in collegiate courses in geophysics, as no other easily read and elementary textbook on the geophysical methods of prospecting is available in English. The thought is not too condensed, the English is clear and pleasing, and the press work is excellent; the book is most interesting and is authoritative. The adverse criticisms are few and minor. The pictures of the torsion balance and seismic methods are perhaps not quite as clear as those of the magnetic, electromagnetic, and electric methods. Many of the comments on the seismic method are considerably out of date. The Mintrop type of seismograph is no longer the leading field seismograph, but has been largely replaced by the electric seismograph, ordinarily of the induction type; the air-wave determination of the explosion time was abandoned approximately four years ago; instead of there being only a vague possibility of value in the reflection method, that method has demonstrated its effectiveness in more complicated situations than has the refraction method, and is in very considerable practical use. A comment on page 21 might give the mistaken impression that most salt domes are magnetic maxima. It is unfortunate that *Geophysical Prospecting, 1929*, published by the American Institute of Mining and Metallurgical Engineers, February, 1929, which ties with Cobb's translation of *Elements of Geophysics* by Richard Ambronn as the most important single reference in English, could not have been added to the bibliography at the last minute. The connection of micropaleontology with geophysics is somewhat attenuated and is no closer than that of geological operations of prospecting with levels, transits, and hand lenses. Petrography, which was not mentioned, is a geophysical method in close parallelism with the seismic method. The reviewer is glad to recommend this book.

Donald C. Barton

Houston, Texas
October 11, 1929

Geologic Map of Arkansas. Prepared by the *Arkansas Geological Survey*, George C. Branner, state geologist (Little Rock, 1929). Colored map (scale 1:500,000), 2 geologic cross sections, and 3 columnar sections, on sheet 36 inches by 51 inches. Price, postpaid, $1.80.

The *Geologic Map of Arkansas*, recently published by the Arkansas Geological Survey, is a compilation of the work of several authors whose published and unpublished data have been edited, for this map, by H. D. Miser and George W. Stose of the U. S. Geological Survey. The scale is the same as the scale of similar geologic maps of Oklahoma, Missouri, and Tennessee,—approximately 1 inch = 8 miles. Township and range lines are shown. There are four geologic-physiographic divisions of Arkansas: (1) Ozark region, (2) Arkansas Valley, (3) Ouachita Mountain region, and (4) Gulf Coastal Plain. This map shows a Southwestern Arkansas area as a subdivision of the Coastal Plain, thus separating the area of Cretaceous outcrop from the area of Tertiary exposures. The Arkansas Valley and the Ozark region (both in the west-central area drained by Arkansas River) and the Coastal Plain (southeastern half of the state) are areas of special importance for petroleum geologists because of their pools of gas, and of oil and gas, respectively. The producing pools are outlined and named. One of the most recently discovered pools, on this map named "Camden" (Ouachita County), has been more generally known in trade journals and scout reports as "Mount Holly."

An outstanding structural feature mapped in the Coastal Plain is the graben fault zone approximately paralleling the strike of the Eocene formations from Miller County northeast through Nevada County, where it seems to lose its identity as a definite northeasterly line of weakness. This particular fault zone is the object of considerable speculation because there is only one producing pool (Irma) located within its length of 50 or 60 miles.

The large number of anticlines mapped in the area of the Arkansas Valley and the southern part of the Ozarks seems to justify the present great interest of oil and gas producers in those parts of the state, where there are already several small pools of gas.

The map is one of several recent publications describing the geology of Arkansas. Others are: "Upper Cretaceous Formations of Southwestern Arkansas," by Carle H. Dane, *Arkansas Geol. Survey Bull. 1;* "Geology of the DeQueen and Caddo Gap Quadrangle, Arkansas," by Hugh D. Miser and A. H. Purdue, *U. S. Geol. Survey Bull. 808;* and "Structure of the Ouachita Mountains of Oklahoma," by Hugh D. Miser, *Oklahoma Geol. Survey Bull. 50.*

J. P. D. Hull

Tulsa, Oklahoma
November 6, 1929

"Upper Cretaceous Formations of Southwestern Arkansas." By Carle H. Dane. *Arkansas Geol. Survey Bull. 1* (Little Rock, 1929). 215 pp., 29 pls., 4 figs. Price: paper, $1.70; cloth, $1.95.

This book is essentially a detailed description and interpretation of the lithology, thickness, extent, and fauna of each of the many formations of

Upper Cretaceous age which crop out in southwest Arkansas. These beds were most irregularly deposited throughout, so it has been discovered, resulting in many disconformities and diastems, the recognition of which constitutes one of the principal results of the present investigation. New names have been given to some of the units, old formations have been re-defined, and others restricted, with the result that the area is now mapped in considerable detail for the first time. This report is therefore a valuable contribution to our knowledge of this region. A colored geologic map, two cross sections, and a correlation chart accompany the report; and numerous faunal lists and local sections of the strata are given in the text. The report is further embellished by several plates of fossils and illustrations of rock exposures, all of which are excellent. In the final pages, as an appendix, there are given numerous logs of wells drilled in the area, with descriptions of samples by H. D. Miser and correlations by C. H. Dane. These are especially helpful to an understanding of the structure of the region.

For the average reader, who is not interested especially in all of the details of Dane's report, the Abstract and Summary of Results, together with the maps and sections, will be found sufficient. If there is any point about the book that is open to criticism it is that too many details have been included. It is well, therefore, that the Abstract and Summary of Results were prepared.

There are extensive deposits of water-laid volcanic ash in the lower part of the Upper Cretaceous of southwest Arkansas, and farther west, which Dane mentions, but these are fully described in a separate paper, namely, "Water-laid Volcanic Rocks of Early Upper Cretaceous Age in Southwestern Arkansas, Southeastern Oklahoma, and Northeast Texas," by C. S. Ross, H. D. Miser, and L. W. Stephenson, *U. S. Geol. Survey Prof. Paper 154-F*, also recently published. This latter report one should not fail to read in connection with the work by Dane, as both papers refer to the same area and to the same series of rocks.

CHARLES W. HONESS

GYPSY OIL COMPANY
TULSA, OKLAHOMA
November 12, 1929

Geologic Structures. By BAILEY WILLIS and ROBIN WILLIS. McGraw-Hill Book Company, Inc. (New York, 1929). Second edition, revised and enlarged. 518 pp., 164 illus. 5 by 7½ inches, pocket edition. Semi-flexible Keratol. Price, $4.00.

This book by Bailey Willis and Robin Willis is a revised, enlarged edition of Bailey Willis' book *Geologic Structures* published in 1926. It is an outstanding work, containing invaluable information for all who are interested in the study of structural geology. It deserves a conspicuous place in every geologist's library, and should command the attention of educators, students, and prospective students. In the introduction the author points out the purpose of the book.

Petroleum geology demands even more thorough training and wider knowledge than mining. I. C. White first identified the occurrence of oil with the trend of an

anticlinal axis in West Virginia and made a fortune out of his confidence in the relation. Thousands of successful wells have since been located by that clue, but many others have failed. They missed the top of the fold, or the structure was not "closed," or it was faulted, or—well, there was some peculiarity of the structure that was responsible for the failure. Perhaps the geologist who located the well could have known it, perhaps he could not, but certainly the more geology he knows and the more intimately he knows anticlines, faults, echelon folds, and many other types of structure on which oil may accumulate, the better his chance of striking it.

A new profession is developing. We have long had geologists and also engineers. We now have the geological engineer. An engineer, competent in mechanics, experienced in construction, able in hydraulics, he also possesses a knowledge of structural geology, knows how rocks behave when deformed in the course of mountain building, and can interpret folds, joints, and faults understandingly.

Thus in practice as well as in research structural geology is an essential feature of the preparation of a man who seeks to advance in the profession of a geologist.

The text is divided into four sections: (1) Description of Rock Structures, (2) Mechanics of Rock Deformation, (3) Methods of Attack, (4) Major Problems of Earth Dynamics.

The first section, which covers about one-half of the book, is primarily for the student. It is exceedingly interesting reading and thoroughly presented. The principles of sedimentation are described, and folding, jointing, and faulting are fully considered. Structure of igneous and metamorphic rocks is also discussed.

Section II has been thoroughly revised and enlarged. The author presents the mechanical principles and types of rock deformations, and an analysis of folding and faulting. The reviewer was particularly impressed with the chapter on analysis of folding. The following is a typical paragraph found in the discussion.

Incompetent folding differs from competent folding in the direction of the deflecting stress and in the character of the resulting tension. As has been stated in the preceding section, competent folding is produced by pressure directed in the planes of the strata, when they are in a nearly horizontal position, and resolved into components parallel to and perpendicular to the beds as they bend. Since the angle which the pressure makes with the bedding is an acute angle, the component parallel to the bedding is larger than that perpendicular to it. The folding mass, considered as a whole, is subject to tension in a vertical direction, as is demonstrated by the spreading in the axial planes of similar folds. Competent folding, therefore, is characterized by horizontal compression and vertical extension.

Section III covers 77 pages dealing with the elements of field practice. Every student will find helpful suggestions in these pages.

The final section covers 86 pages and is entirely new. Bailey Willis discusses Earth Genesis, Constitution of the Earth, Zones of Pressure, Strength, and Temperature in the Outer Crust, and Dynamic Spheres of the Globe in an intensely interesting manner. There is not a dull line, and the reading of this part of the text has caused the reviewer to style Bailey Willis the "Will Durant of Geology." Notice the following passages.

The planet we call the earth is a child of the sun, and like its parent star it consists of energy and matter.....

Our thinking is dominated by the inherited notion that the earth is dead, or at any rate dying.....

Life on earth is, however, a different thing from life within or of the earth. We think of the globe itself as being "as dead as a stone" and are surprised when it bestirs itself, as in an earthquake.....

Gravity.—A persistent attraction, definite and invariable in direction, omnipresent and unceasing; constant for any given mass in a fixed position, so long as the rate of rotation of the earth is constant; varying as the densities of different masses and inversely as the distance to the center of attraction; attracts most strongly at 610 miles below the surface and diminishes to zero at the center.....

Compression normally controls expansion, but compression and expansion wrestle with one another in constant and unrelaxing opposition. If pressure lessens, expansion instantly ensues. If temperature falls, compression immediately takes place. The rock responds at once to the slightest change in the conditions of its environment by a corresponding change in volume.

ELFRED BECK

TULSA, OKLAHOMA
November, 1929

RECENT PUBLICATIONS

AFRICA

"Drilling on the Gold Coast, West Africa," by O. A. L. Whitelaw. *Jour. Inst. Petrol. Tech.* (London, October, 1929), Vol. 15, No. 76, pp. 574-87. 6 figs.

AVIATION

"Aerial Photography Proves Its Importance to California Geologists," by Leon T. Eliel. *Oil Bulletin* (Los Angeles, California, November, 1929), pp. 1,177-81; 1,253. 5 illus.

"And What of the Dirigible? Does It Offer Advantages Over the Airplane for Reconnaissance work?" by Walker S. Clute. *Oil Bulletin* (November, 1929), pp. 1,182-83. 2 illus.

"Over the Oil Fields in a Dirigible," by Richard Fenton. *Oil Bulletin* (November, 1929), pp. 1,194-95; 1,252. 2 illus.

"Airway Maps of the Department of Commerce and the Army Air Corps." Airway strip maps (scale of 1:500,000, or 8 miles = 1 inch) covering an area 80 miles wide along established airways. For list of maps, address U. S. Coast and Geodetic Survey, Washington, D. C. Price per map, $0.35.

CROOKED HOLES

"Miniature Rig for Crooked Hole Tests," *Oil and Gas Journal* (Tulsa, Oklahoma, November 14, 1929), pp. 41, 148. 4 illus. Reprinted from *Union Oil Bulletin*. Also see "Union Oil Gets a Strangle Hold on the Crooked Hole Problem," *Petrol. World and Oil Age* (Los Angeles, California, November, 1929), pp. 75-78. 8 illus.

"New Surveying Instrument." *Petrol. World and Oil Age* (November, 1929), p. 111. 1 fig.

GENERAL

"Contributions to Economic Geology," by H. D. Miser. *U. S. Geol. Survey Bull. 806*, Part II, Mineral Fuels. Papers on Pumpkin Buttes Coal Field, Wyoming; Sheridan Coal Field, Montana; Oil and Gas Prospects, San Rafael Swell, Utah; Rock Creek Oil Field, Wyoming; and Oil Possibilities near Highwood Mountains, Montana—all previously published as advance

chapters. 195 pp., 44 pls. (including 7 maps), 19 figs. Supt. Documents, Washington, D. C. Price, $0.75.

"Electrical Logs and Correlations in Drill Holes," by Conrad and Marcel Schlumberger. *Mining and Metallurgy* (New York, November, 1929), Vol. 10, No. 275, pp. 515-18. 7 figs.

Reply to Sidney Powers' "Collines enterrées (Buried Hills) et champs pétrolifères du Monde" (published in *Revue Pétrolifère*, August 24, 1929, pp. 1,091-92, 2 figs.), by C.-P. Nicolesco. *Revue Pétrolifère* (Paris, France, November 2, 1929), pp. 1,556-57.

"Prospections géophysiques en Limagne," by M. P. Geoffroy. *Annales des Combustibles Liquides* (Paris, France), No. 4 (July-August, 1929), pp. 617-48. 5 figs. 4 pls.

ILLINOIS

"Oil and Gas Developments in St. Clair, Monroe, Randolph, and Washington Counties, Illinois," *Illinois State Geol. Survey Press Bull. Series Illinois Petroleum No. 18* (Urbana, 1929). Price, $0.25.

LOUISIANA

"Zwolle Oil Field of Louisiana," by H. D. Easton. *Oil Weekly* (Houston, Texas, November 1, 1929), pp. 30-31.

ROUMANIA

"Geological Structure of Roumanian Oil Fields," by H. E. Cassidy. *Oil Weekly* (October 25, 1929), pp. 30-32. 3 geologic sections.

THE ASSOCIATION ROUND TABLE

ON SPONSORING APPLICATIONS FOR MEMBERSHIP

During the last few months we have heard several instances of carelessness or lack of responsibility of members in signing their names as sponsors for applicants for membership in the A. A. P. G.

First, a sponsor must be an active member himself; an associate member can not serve as a sponsor.

Second, a sponsor should actually know the applicant, and well enough to be in a position to give the executive committee an adequate and truthful statement of his opinion of the applicant's qualifications and character. If you, as a sponsor, can not do this, then you should not sign your name as sponsor for that applicant.

Third, we believe that there is generally a tactful way of informing an applicant that you do not feel justified in sponsoring him if such is the case. It would be much better to be frank with him than to write your signature on his application and withdraw it subsequently.

F. H. L.

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The Executive Committee has approved for publication the names of the following applicants for membership in the Association. This does not constitute an election, but places the names before the membership at large. If any member has information bearing on the qualifications of these applicants, please send it promptly to J. P. D. Hull, Business Manager, Box 1852, Tulsa, Oklahoma. (Names of sponsors are placed beneath the name of each applicant.)

FOR ACTIVE MEMBERSHIP

Arthur Alan Baker, Washington, D. C.
Hugh D. Miser, W. T. Thom, Jr., W. C. Mendenhall

Calvin James Dean, Bakersfield, Calif.
C. M. Wagner, Leo S. Fox, W. E. James

Frank Goldstone, Dallas, Tex.
W. Dow Hamm, K. H. Schilling, Angus McLeod

Edgar Allen Keeler, Tulsa, Okla.
Edward Bloesch, E. P. Philbrick, S. D. Butcher

F. C. Wood, Jr., Ponca City, Okla.
Dean E. Winchester, A. E. Brainerd, R. L. Heaton

FOR ASSOCIATE MEMBERSHIP

Jack J. Berry, Tulsa, Okla.
C. A. Yoakam, L. W. Kesler, Vaughn W. Russom
Hastings M. Faulkner, Meridian, Miss.
B. W. Blanpied, James D. Aimer, Corbin D. Fletcher
Graham Johnston, Shreveport, La.
M. W. Grimm, W. F. Chisholm, Roy J. Metcalf
Ludvig Carl Lindeblad, Bartlesville, Okla.
I. J. Vernon, E. E. Lindeblad, E. F. Schramm
B. G. Martin, Meridian, Miss.
B. W. Blanpied, Corbin D. Fletcher, James D. Aimer
Charles E. Moser, Los Angeles, Calif.
George H. Doane, Rouse Simmons, C. R. McCollom
Karl Mygdal, Maracaibo, Venezuela, S. A.
C. F. Bassett, William H. Spice, Jr., J. B. Burnett
Willard M. Payne, Tulsa, Okla.
A. A. Langworthy, H. N. Coryell, H. R. Van Gilder
Dwight H. Sanford, Eden, Tex.
R. A. Conkling, G. J. Scholl, F. B. Plummer
Lawrence P. Spencer, Shawnee, Okla.
J. K. Knox, C. R. Hoyle, G. S. Lambert
James A. Tierney, Jr., Meridian, Miss.
B. W. Blanpied, Corbin D. Fletcher, James D. Aimer

FOR TRANSFER TO ACTIVE MEMBERSHIP

Henry Rogatz, Amarillo, Tex.
J. K. Knox, J. J. Maucini, Lawrence R. Hagy
Walter H. Spears, New York, N. Y.
Carroll H. Wegemann, Ezequiel Ordoñez, E. L. Estabrook
C. A. Stewart, San Antonio, Tex.
E. L. Porch, Jr., Charles H. Row, Herschel H. Cooper
Rual B. Swiger, San Antonio, Tex.
Charles H. Row, R. F. Schoolfield, Martin Matson

NEW ORLEANS MEETING, MARCH 20-22, 1930

Arrangements for the program of the 15th annual meeting of the A. A. P. G. at New Orleans, Louisiana, March 20-22, 1930, are being made by the following committees.

GENERAL ARRANGEMENTS

J. Y. Snyder, *president*, 1211 City Bank Bldg., Shreveport, Louisiana
Fred H. Kay, *1st vice-president* A. R. Denison, *2nd vice-president*
R. S. McFarland, *past-president* F. H. Lahee, *3rd vice-president*

TECHNICAL PROGRAM

F. H. Lahee, *general chairman*, Box 953, Dallas, Texas

Gulf Coast Papers

W. C. Spooner, *chairman*, Box 1195, Shreveport, Louisiana

A. F. Crider — W. Armstrong Price
Phillip S. Justice — R. A. Steinmayer
Donald J. Munroe

Foreign Papers

G. C. Gester — W. B. Heroy

Geophysical Papers

D. C. Barton, *chairman*, Petroleum Bldg., Houston, Texas

Crooked Hole Papers

F. H. Lahee, *chairman*, Box 953, Dallas, Texas

S. P. Borden	P. S. Justice	C. H. Row
A. R. Denison	Marvin Lee	F. C. Sealey
E. L. Estabrook	T. A. Link	D. R. Snow
W. P. Haynes	R. P. McLaughlin	W. C. Thompson
O. B. Hopkins	J. C. Montgomery, Jr.	S. H. Woods
W. E. Hubbard	J. French Robinson	

SHREVEPORT COMMITTEE

M. W. Grimm, *chairman*, 315 Ward Bldg., Shreveport, Louisiana

S. P. Borden — C. M. Dorchester
W. F. Chisholm — W. E. Hopper

RECEPTION

R. A. Steinmayer, *chairman*, Tulane University, New Orleans, Louisiana

A. F. Crider — H. V. Howe
Roy Hazzard — W. C. Spooner

"STUNT NIGHT ON THE MIGHTY MISSISSIPPI"

George R. Stevens, *chairman*, 324 Washington Ave., Shreveport, Louisiana

L. A. Barton — L. S. Harlowe
E. H. Finch — Paul Madden

LADIES

Mrs. S. P. Borden, *gen'l chairman*, 837 Dudley Drive, Shreveport, Louisiana
Mrs. R. A. Steinmayer, *local chairman*, Tulane University, New Orleans, Louisiana

Mrs. A. F. Crider — Mrs. J. Y. Snyder
Mrs. H. V. Howe — Mrs. G. R. Stevens

SPECIAL NEW ORLEANS TRIPS

R. A. Steinmayer, *chairman*, Tulane University, New Orleans, Louisiana
John L. Henning

HISTORIC EVANGELINE-COUNTRY TRIP

J. S. Ivy, *chairman*, 1100 City Bank Bldg., Shreveport, Louisiana

C. C. Clark — G. W. Schneider
J. O. Nelson — C. L. Rankin

Arrangements for finance, publicity, registration, entertainment, golf tournament, exhibitors' space, and other matters are in charge of the executive committee of the A. A. P. G. with the active coöperation of the New Orleans Convention and Publicity Bureau, Inc., Sam Fowlkes, executive director, and the management of the Roosevelt Hotel. Hotel reservations are in charge of the Roosevelt. Detailed information and reservation cards will soon be sent to each member. Further information about arrangements will be issued from time to time. General inquiries and communications should be directed to Association headquarters, Box 1852, Tulsa, Oklahoma.

TENTATIVE ORDER OF EVENTS FOR NEW ORLEANS MEETING, ROOSEVELT HOTEL, CONVENTION HEADQUARTERS

WEDNESDAY, MARCH 19

A. M. Registration, Venetian room, Lobby floor
Executive Committee meeting, Mezzanine
Research Committee meeting, Mezzanine

P. M. General Business Committee meeting, Mezzanine

THURSDAY, MARCH 20

A. M. Convention opens. Address of welcome, Tip-Top Inn, 12th floor
Official response
Appointment of committees for the meeting
Technical sessions

P. M. Technical sessions, Tip-Top Inn and Mezzanine
Ladies. Trip through Vieux Carre
Nomination of officers, Tip-Top Inn
"Stunt Night on the Mighty Mississippi"

FRIDAY, MARCH 21

A. M. Ballot boxes open, Venetian room, Lobby floor
Technical sessions, Tip-Top Inn and Mezzanine
Ladies. Bridge and luncheon

P. M. Technical sessions
Golf tournament. Bostick trophy
Ladies. Sight-seeing on Steamer "Capitol"
Buffet dance, Tip-Top Inn

SATURDAY, MARCH 22

A. M. 15th annual business meeting, Tip-Top Inn
Announcement of elections
Technical sessions

P. M. Technical sessions
No entertainment has been scheduled for Saturday so that individual inclinations may be followed. The Special Trips Committee in the Venetian room will be glad to suggest points of interest.

Registration

Registration desk in the Venetian room, off the Lobby, near the University Place entrance of the Roosevelt Hotel. Each member or guest is expected to register promptly. The registration fee, $3.00, secures tickets to technical and social events.

Exhibits

Laboratory, office, and field equipment. Venetian room. Lobby floor.

Geological exhibits. Suitable space provided for maps, charts, et cetera, in the Venetian room. Only illustrations accompanying papers will be shown at the technical sessions in the Tip-Top Inn.

PACIFIC SECTION ANNUAL MEETING

The Pacific Section of the A. A. P. G. held its annual fall meeting at San Francisco, California, November 21 and 22, 1929. Technical sessions were held at the Pacific Gas and Electric Company's auditorium. A dinner dance was held in the Rose Room of the Palace Hotel. Outgoing officers of the section are Earl Noble, president, and E. M. Butterworth, secretary-treasurer. Officers for the new year were elected as follows: Ralph D. Reed, *president*, 1717 South Third Street, Alhambra, California., H. K. Armstrong, *secretary-treasurer*, 453 Roosevelt Building, Los Angeles, California.

The following papers were presented at the technical sessions.

"Recurrent Movements on Palomas Canyon Fault, Los Angeles County, California," by G. H. White.

"Orientation of Cores," by George A. Macready.

"Geology of Santa Rosa Island, Santa Barbara County, California," by Bruce Seymour.

"Age of the Uppermost Signal Hill Fauna," by W. Farrand and A. J. Tieje.

"Sandstone Dikes as Conduits for Oil Migration Through Shales," by Olaf P. Jenkins.

"Geology of the West Side of the Salinas Valley, Monterey County, and San Luis Obispo County, California," by J. M. Kirby and H. W. Weddle.

"Relationship of Vulcanism to Deposition of Siliceous Shale," by N. L. Taliaferro.

"The McLure Shale of the Coalinga Region," by Gerhard Henny.

"Some Features of the Coastal Region of Santa Barbara County, California," by W. E. James.

"Miocene Brown Shale of the Kettleman Hills, California," by H. G. Schenck.

"Micro-Organisms of the Marine Siliceous Shales of California," by G. D. Hanna.

"The Topango Canyon Diatom Flora," by Kenneth E. Lohman.

"Sandstone Lenses in the Maricopa Shale," by Louis N. Waterfall.

"The Fauna of the Kreyenhagen Shale," by Fritz von Estorff.

"The *Foraminifera* of the Reliz Canyon Monterey Shale," by Robert Kleinpell.

"Silicification of Monterey Shale," by F. S. Hudson.

"Some Problems of the Monterey Shale," by R. D. Reed.

AT HOME AND ABROAD

WANTED—IDEAS

The committee appointed to consider revising the constitution requests ideas and suggestions for the improvement of the constitution and by-laws. The committee would like to have every member read the constitution and by-laws (*Bulletin* for June, 1929, pp. 703-6) and write the committee or tell some member. The committee is as follows.

MAX W. BALL, First National Bank Building, Denver, Colorado
SIDNEY POWERS, Amerada Petroleum Corporation, Petroleum Building, Tulsa, Oklahoma
DONALD C. BARTON, Petroleum Building, Houston, Texas
G. R. STEVENS, 324 Washington Avenue, Shreveport, Louisiana
C. R. MCCOLLOM, 832 Petroleum Securities Building, Los Angeles, California
ANTHONY FOLGER, Box 1144, Wichita, Kansas
R. C. COFFIN, First National Bank Building, Denver, Colorado

C. E. YAGER, who has been assistant chief geologist for the Texas Pacific Coal and Oil Company, Fort Worth, Texas, has succeeded DAVID DONOGHUE as chief. THOMAS B. ROMINE, who has been stationed at Grand Falls, Montana, has been transferred to Fort Worth as assistant to Mr. Yager.

J. S. IRWIN, formerly chief geologist of the Producers and Refiners Corporation in Rocky Mountain territory, and a Denver consultant, has gone to Canada as chief geologist of the Nordon Corporation, Ltd.

T. F. NEWMAN has resigned from the Midwest Exploration Company at Amarillo, Texas, and has joined the geological department of the Skelly Oil Company as district geologist in the Amarillo office.

A. F. MELCHER, of Tulsa, Oklahoma, has established the Petroleum Engineering Laboratories (a branch of his Tulsa Petroleum Engineering Laboratories) in the Holley Hotel Building, Bradford, Pennsylvania, and has commenced work for Bradford operators.

C. E. DOBBIN, of the U. S. Geological Survey, who has had headquarters at Denver, Colorado, for some time, is stationed for the winter at Roswell, New Mexico.

Section E, Geology and Geography, of the American Association for the Advancement of Science, will meet at Des Moines, Iowa, December 30 and 31, 1929. The Brown Hotel, 4th and Chestnut Streets, is to be headquarters. Further information may be obtained from Kirtley F. Mather, secretary of

Section E, Geological Museum, Harvard University, Cambridge, Massachusetts.

ROBERT J. RIGGS, of the Indian Territory Illuminating Oil Company, Bartlesville, Oklahoma, gave a paper on "The Oklahoma City Oil Pool," and R. L. GINTER, consulting chemist, Tulsa, Oklahoma, gave a paper on "Sulphate Reduction of Oil-Field Waters," before the Tulsa Geological Society, November 4, 1929.

C. S. CORBETT, geologist with the Gulf Oil Corporation, read a paper on "Procedure for Exploitation of Oil-Bearing Structure by Unit Operation," before the Petroleum Division of the A. I. M. E. at Tulsa, Oklahoma, October, 1929. The paper appeared in the *Oil Weekly* of November 8, 1929.

The Geological Society of America will hold its Forty-Second Annual Meeting at Washington, D. C., December 26-28, 1929, under the auspices of the Geological Society of Washington, the U. S. Geological Survey, and the National Museum. The Wardman Park Hotel, Woodley Road and Connecticut Avenue, is hotel headquarters. For further information address the secretary, Professor Charles P. Berkey, Columbia University, New York, N. Y.

H. DE CIZANCOURT is now in Paris after a four-month trip in Venezuela and Morocco.

WALLACE C. THOMPSON, formerly in charge of geological work for the Sun Oil Company at Wichita Falls, Texas, now has similar responsibilities for his company at Tyler, Texas.

MAX W. BALL, of Denver, Colorado, has been appointed by president J. Y. SNYDER as member-at-large on the general business committee for the 15th annual meeting of the A. A. P. G. at New Orleans, March 20-22, 1930.

JOSEPH E. POGUE, consulting engineer of New York City, presented a paper on "The Economic Trend of the Petroleum Situation" before the Tulsa meeting of the Petroleum Division, A. I. M. E., Tulsa, Oklahoma, October 4, 1929. The paper was published in *Mining and Metallurgy* for November, 1929.

DJEVAD EYOUB has left Tampico, Mexico, to accept an invitation from the Republic of Turkey to investigate the petroleum possibilities of the country. Mr. Eyoub went through France and Roumania. He expects to spend a year in preliminary examinations. His address is Iktisat Vekaleti Petrol Kismi, Angora, Turkey.

CARY P. BUTCHER, formerly with the Continental Oil Company at San Angelo, Texas, is now engaged in work in West Texas and southern New Mexico. He is located at San Angelo, with Cranfill and Reynolds.

DAVID WOSK will be in charge of the land and geological departments of the White Eagle Oil and Refining Company, which is moving its offices from Abilene to Fort Worth, Texas.

F. F. HINTZE, formerly of Denver, Colorado, is now associate professor of geology at the University of Utah, Salt Lake City.

CARL H. BEAL, California representative of the Independent Oil and Gas Company of Oklahoma, has opened offices in Los Angeles.

HUGO DE BOCKH, principal geological adviser to the Anglo-Persian Oil Company, has been appointed director of the Geological Survey of Hungary.

H. FOSTER BAIN, secretary of the A. I. M. E., outlined his recent trip to Colombia, before the Tulsa Geological Society and the Tulsa section of the A. I. M. E., November 18, 1929. Dr. Bain was one of the advisers to the Colombian Government on the matter of framing a law governing the exploitation of petroleum in that country.

IRA H. CRAM, of The Pure Oil Company, read a paper on "The Stratigraphy of Eastern Oklahoma" before the Tulsa Geological Society, November 25, 1929.

H. D. EASTON, consulting geologist, Ardis Building, Shreveport, Louisiana, reports that the following books may be interesting to members planning to attend the New Orleans meeting, March 20-22, 1930: *Fabulous New Orleans* and *Old Louisiana* by Lyle Saxon, published by The Century Company.

President J. Y. SNYDER appointed HUGH D. MISER and WILBUR A. NELSON, of the Capital district, to represent the Association at the meeting of the American Mining Congress at Washington, D. C., December 4-7, 1929.

ROBERT B. MORAN, consulting geologist of Los Angeles, California, accompanied by his son Robert, left Los Angeles on October 28 for Lima, Peru. He expected to spend the months of November and December in studying some of the geology in parts of Peru and Ecuador. He will return to Los Angeles shortly after the first of the year.

WILBUR A. OBORNE, formerly of the Lago Petroleum Corporation at Maracaibo, Venezuela, is no longer connected with that company, but is working for private interests in Paris. His address is 15 Carrefour de L'Odeon, Paris VI, France.

EARL EMENDORFER, recently in Colombia, S. A., for the Tropical Oil Company, has returned to the United States. His address is 1377 Monroe Street, Hammond, Indiana.

H. D. EASTON, consulting geologist of Shreveport, Louisiana, has a paper on "Northwest Arkansas Possibilities" in the *Oil and Gas Journal* for November 21, 1929.

GEORGE A. KROENLEIN, consulting geologist of San Angelo, Texas, describes a "Deep Test in Terrell County, Texas," in the *Oil and Gas Journal* of November 21.

The Sullivan Machinery Company has issued *Bulletin 85-K* (October, 1929) on "Core Drilling for Structure with Sullivan Diamond Drills."

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ERRATA

Page 5, line 1: the word "truck" should be *tank*.

Page 8, Plate 1, Figure 1: the letter *A* should appear at side of figure at contact of black and light gray horizons.

Page 8, Plate 1, Figure 2: the two black horizons should be labelled *A* and *B*, *B* being the higher and marked "Sand."

Page 8, Plate 1, Figure 3, and Page 9, Plate 2, Figures 4 and 5: the five black horizons shown should be labelled *A*, *B*, *C*, *D*, and *E*, beginning with the bottom black horizon; in each figure the horizon marked "Sand" is horizon *B*.

Page 11, Plate 3, Figure 6: of the two broken black lines extending up and over the dome, the lower should be labelled *A* and the higher, *B*. The upper surface of the horizon marked "Sand" should be labelled *C*.

Page 11, Plate 3, Figure 7: the two thin black horizons at the base of the horizons marked "Sand" are *A* for the lower and *B* for the higher.

Page 11, Plate 3, Figure 8: the contact of the black and gray horizons at the middle of the section is *A*.

Page 13, Plate 4, Figures 9 and 10: the five black horizons extending all the way across the sections are *A*, *B*, *C*, *D*, *E*, respectively, from bottom upward.

Page 397, lines 21 and 29: "Far" should be *Fars*.

Page 398, Table I, column 1: "Far" should be *Fars*.

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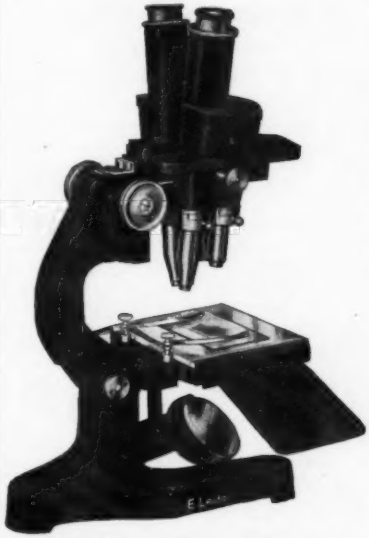

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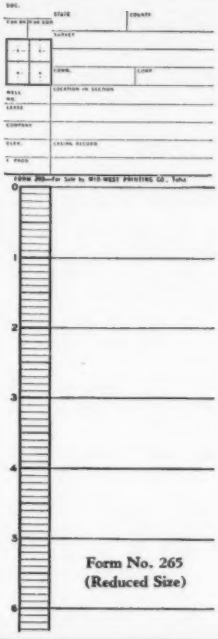

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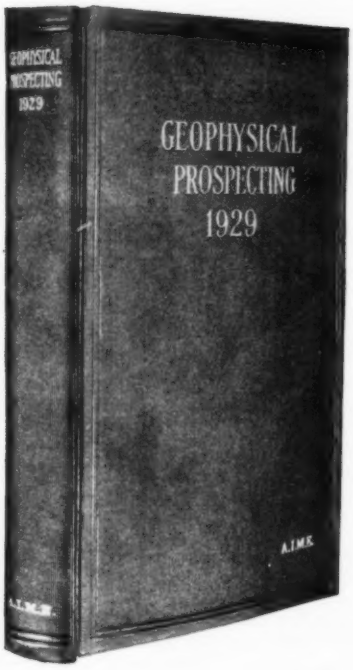

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ERRATA

Page 740, line 1: "many" should be *may*.

Page 741, line 10: "continuents" should be *continents*.

Page 741, line 25: "constituents" should be *continents*.

Pages 741 and 801-8: "John Wray" should be John *Ray*.

Page 1173: normal equations (*4*), $2X_3$ should read 2×3; the minus sign should be changed to *plus* for d, $2\times 3Y$, and $2(b-c-f)$.

Pages 1171 and 1173: for W read Z; for Y read W, and for Z read Y.

Page 1176, Figure 4: reverse the arrows of d, e, and f. Figure 5: X_3 and X_4 of the figure should be interchanged.

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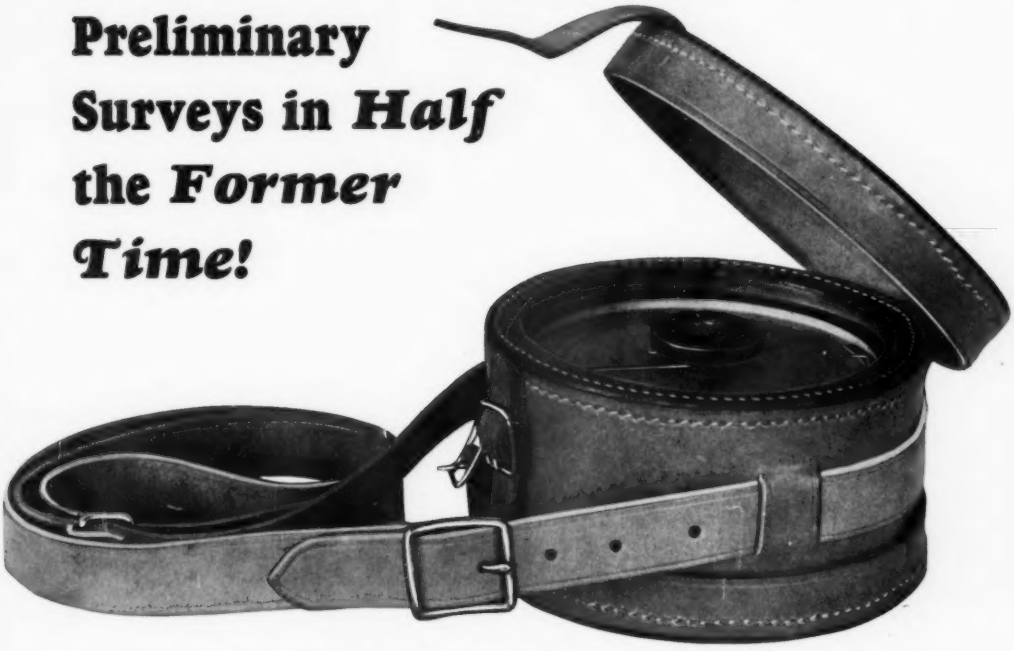

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Service Plants
Los Angeles, Calif.
Oklahoma City, Okla.

Export Office
Woolworth Bldg.
New York City